TECHNOLOGY DEPT.

RUBBER WORLD

OUR 65th YEAR

A BILL BROTHERS PUBLICATION

AUGUST, 1954

Worldwide....
CABOT THERMAL
CARBON BLACKS
for Natural Rubber Tubes
Mechanical and Extruded Goods...

A Complete Range
Sterling® FT FINE THERMAL
Sterling® MT MEDIUM THERMAL
Sterling® MT Non-Staining MEDIUM THERMAL NON-STAINING

BOSTON 10, MASS.

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Hot Stuff

Temperatures far above those encountered in any other phase of the rubber industry are responsible for the reinforcing pigments now so widely used.

Philblack* for example, is a product of "pyrolysis" which is chemical decomposition by the action of heat.

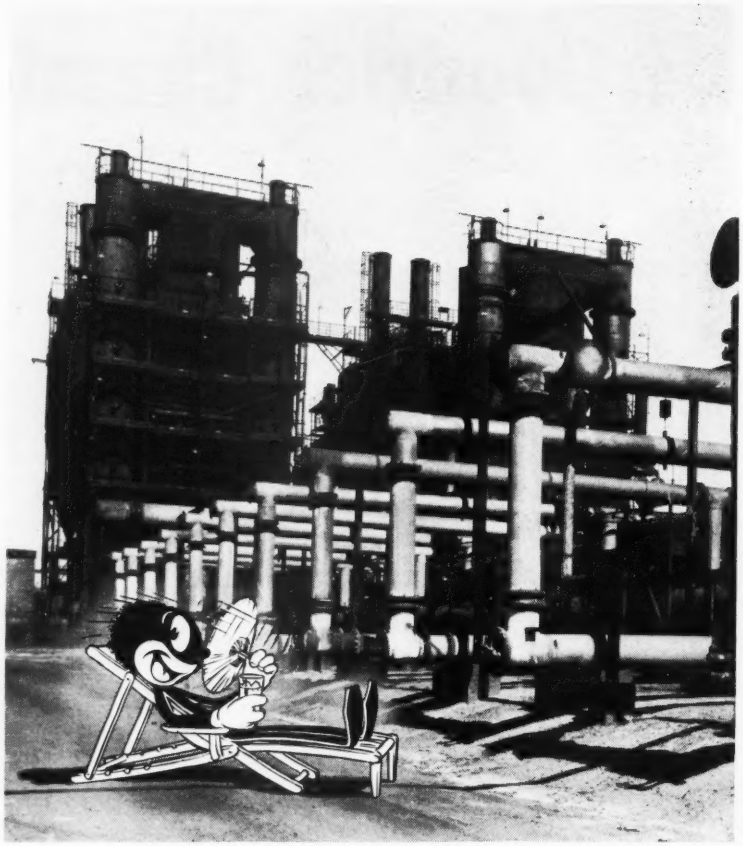
Extremely accurate temperature control is maintained. Philblack oil feed is elevated hundreds of degrees Fahrenheit in a matter of micro-seconds.

The superheated gases are then water-quenched at just the right split-second and gradually cooled further in atmospheric cooling pipes and water spray towers until they are cool enough for bag filters.

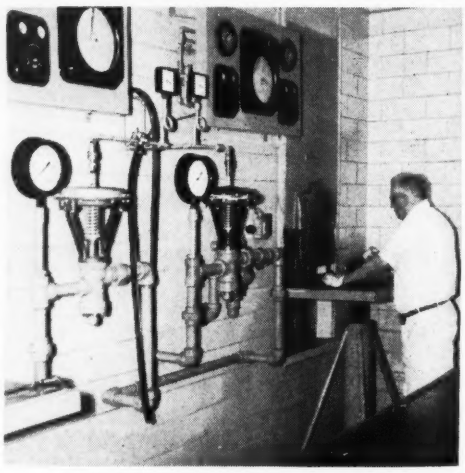
Production samples of Philblack are then regularly submitted in our Customer Service laboratory to carefully controlled temperatures in Banbury mixers and during vulcanization. All of which has given us a fine understanding of the role that heat plays in the ultimate value of Philblacks in your rubber products.

Think of us when you have a "hot" problem in rubber compounding. Our technical staff is fully equipped to assist you in all phases of rubber processing and product evaluation.

*A TRADEMARK



Atmospheric cooling pipes at the world's largest furnace black plant which is operated by Phillips Chemical Company in the Texas Panhandle.



Vulcanizing press at our Akron-Sales-Service Laboratory is used to produce samples for product evaluation. Have any of your products or recipes had the benefit of our testing? Ask your Philblack technical representative for full information.

Know the Philblacks!

KNOW WHAT THEY'LL DO FOR YOU!

A **Philblack A FEF Fast Extrusion Furnace**
Ideal for smooth tubing, accurate molding, satiny finish. Mixes easily. High, hot tensile. Disperses heat. Non-staining.

I **Philblack I ISAF Intermediate Super Abrasion Furnace**
Superior abrasion resistance at moderate cost. Very high resistance to cuts and cracks. More tread miles at high speeds.

O **Philblack O HAF High Abrasion Furnace**
For long, durable life. Good electrical conductivity. Excellent flex. Fine dispersion.

E **Philblack E SAF Super Abrasion Furnace**
Toughest black on the market. Extreme abrasion resistance. Withstands aging, cracking, cutting and chipping.

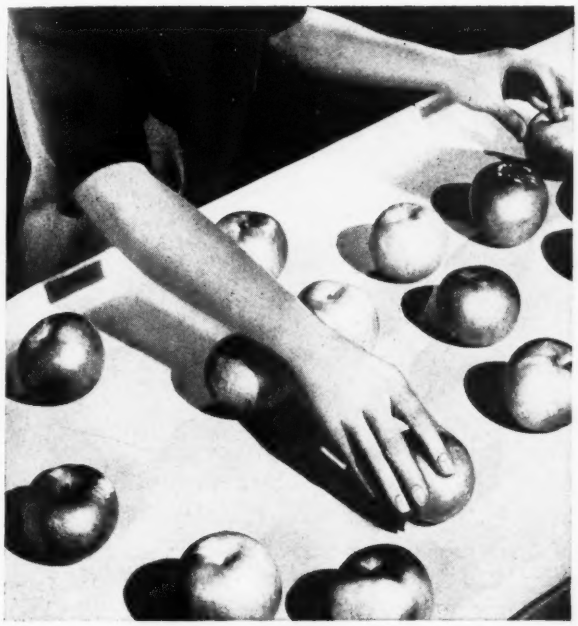
Phillips 66

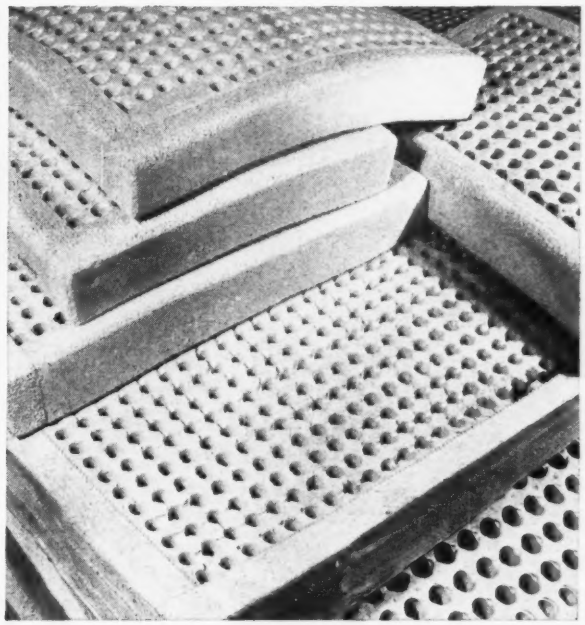
PHILLIPS CHEMICAL COMPANY, Philblack Sales, 318 Water Street, Akron 8, Ohio. Export Sales: 80 Broadway, New York 5, N. Y. West Coast: Harwick Standard Chemical Company, Los Angeles, California. Canada: H. L. Blachford, Ltd., Montreal and Toronto.

SPECIAL ALDEHYDEAMINE ACCELERATORS

for Finer Rubber Specialties

The world's leader in rubber chemicals offers you a series of strong high-temperature accelerators for a wide variety of special rubber-curing needs—for use in mold, open steam, air, and ammonia cures, with both natural and synthetic rubbers.





BEUTENE® is a fast-curing accelerator, moderately non-scorchy at processing temperatures. Compatible with channel and furnace blacks, reclaimed rubber, and acidic softeners, though hard clays retard its action, Beutene is most widely used for hard rubber, molded mechanicals, and wire insulation.

HEPTEEN BASE,® recommended especially for natural rubber, pure gum stocks, gives outstanding tensile and aging with excellent processing safety. Retarded by acidic materials, it is activated by and works well with the more basic furnace blacks. Applications include diaphragms, bladders, thread, and ammonia-cured footwear.

TRIMENE BASE,® with its tendency to stiffen uncured rubber mixes, together with its rapid cure rate, is particularly effective as a heat sensitizer and film stiffener for both natural and GR-S foam sponge. It is also widely used in air-cured footwear, sheeting and proofed goods, molded sundries, specialties, and latex tire cord dip.

TRIMENE® has a definite plasticizing action which helps reduce stock mixing temperatures, and hence scorch. Particularly recommended for use in sponge rubber, especially where a smooth, firm surface skin is desired, Trimene may be used in the same dry rubber applications as Trimene Base, wherever stearic acid bloom is not objectionable.

For more on these important specialty accelerators, write on your letterhead to the address below.

50TH ANNIVERSARY 1904 NAUGATUCK 1954 NAUGATUCK CHEMICAL

Naugatuck Chemical

138 ELM STREET
NAUGATUCK
CONNECTICUT

Division of UNITED STATES RUBBER COMPANY

IN CANADA: NAUGATUCK CHEMICALS DIVISION • Dominion Rubber Company, Limited, Elmira, Ontario

Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices

FINER FLOORING IS MADE FASTER

with new, dry blending PLIOVIC DB80V

FASTER mixing and a shorter heat history are the basic advantages of making flooring with dry blending PLIOVIC DB80V. These, in turn, lead to other benefits in the forms of greater total throughput, better development of cleaner colors, improved heat and light stability, less deterioration of physical properties and longer service life.

PLIOVIC DB80V is a straight polyvinyl chloride resin. But it's tailor-made to provide the properties needed in a good, dry blending resin. It absorbs plasticizer at a rapid, uniform rate. It gives a sandy, free-flowing mix that does not pack or bridge. And it does so with no sacrifice in processing characteristics or physical properties.

PLIOVIC DB80V is no happy accident, but the result of much research and development and carefully controlled production. The secret of its success as a dry blending resin lies in the close control exercised over its particle size, structure and distribution. Particles of DB80V are dry, free-flowing, irregular in surface and remarkably uniform in size.

Three other features of PLIOVIC DB80V which flooring makers find to their liking are its high degree of uniformity, its excellent heat stability and its thorough fluxing. These add up to more capacity on existent equipment and more consistent production with fewer rejects.

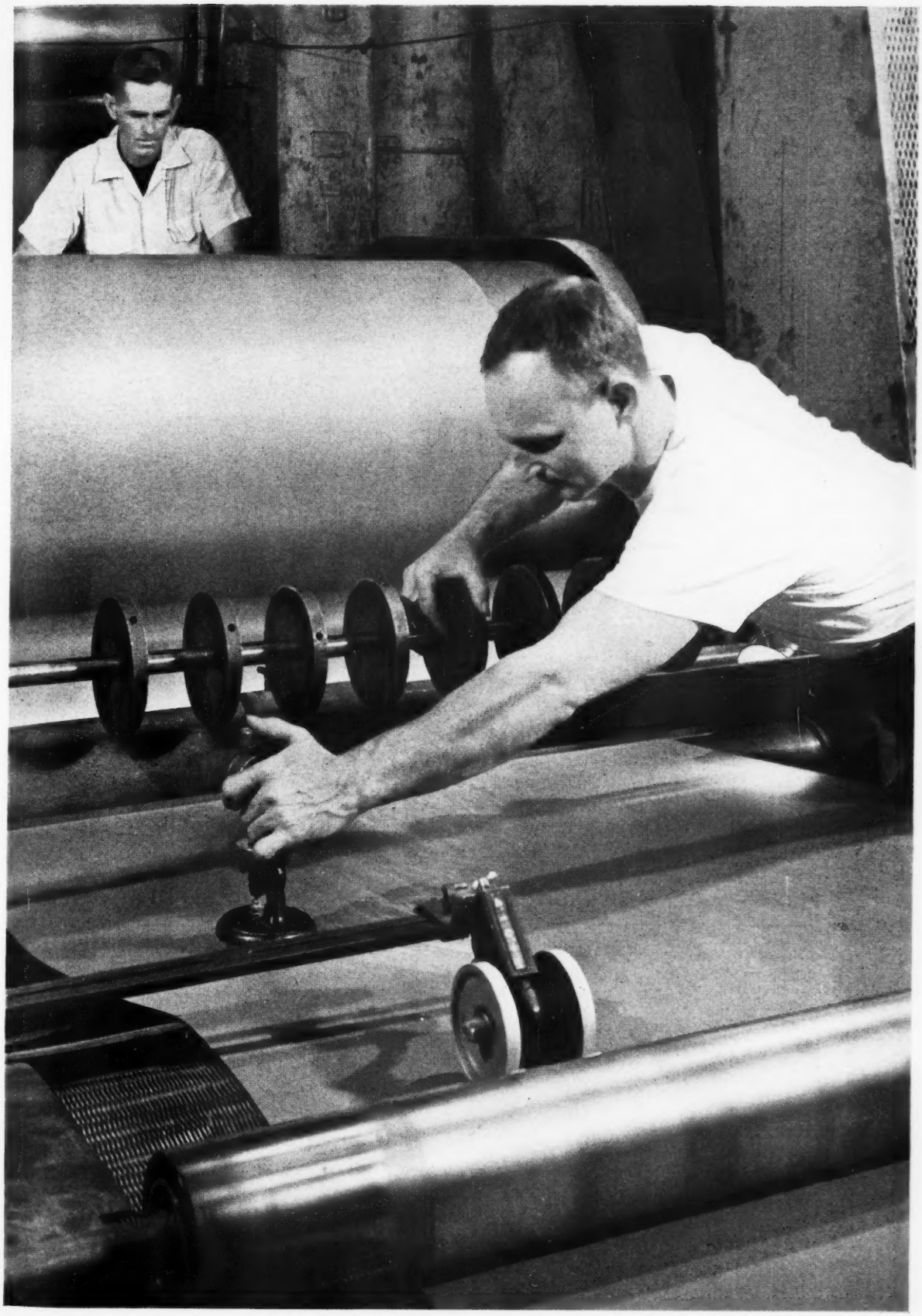
PLIOVIC DB80V is new, but not untried. It has fully proved its mettle in many tests and trial runs and in actual production. Why not let it prove itself in your plant? Samples and technical help are yours for the asking. Just write to:

Goodyear, Chemical Division, Akron 16, Ohio

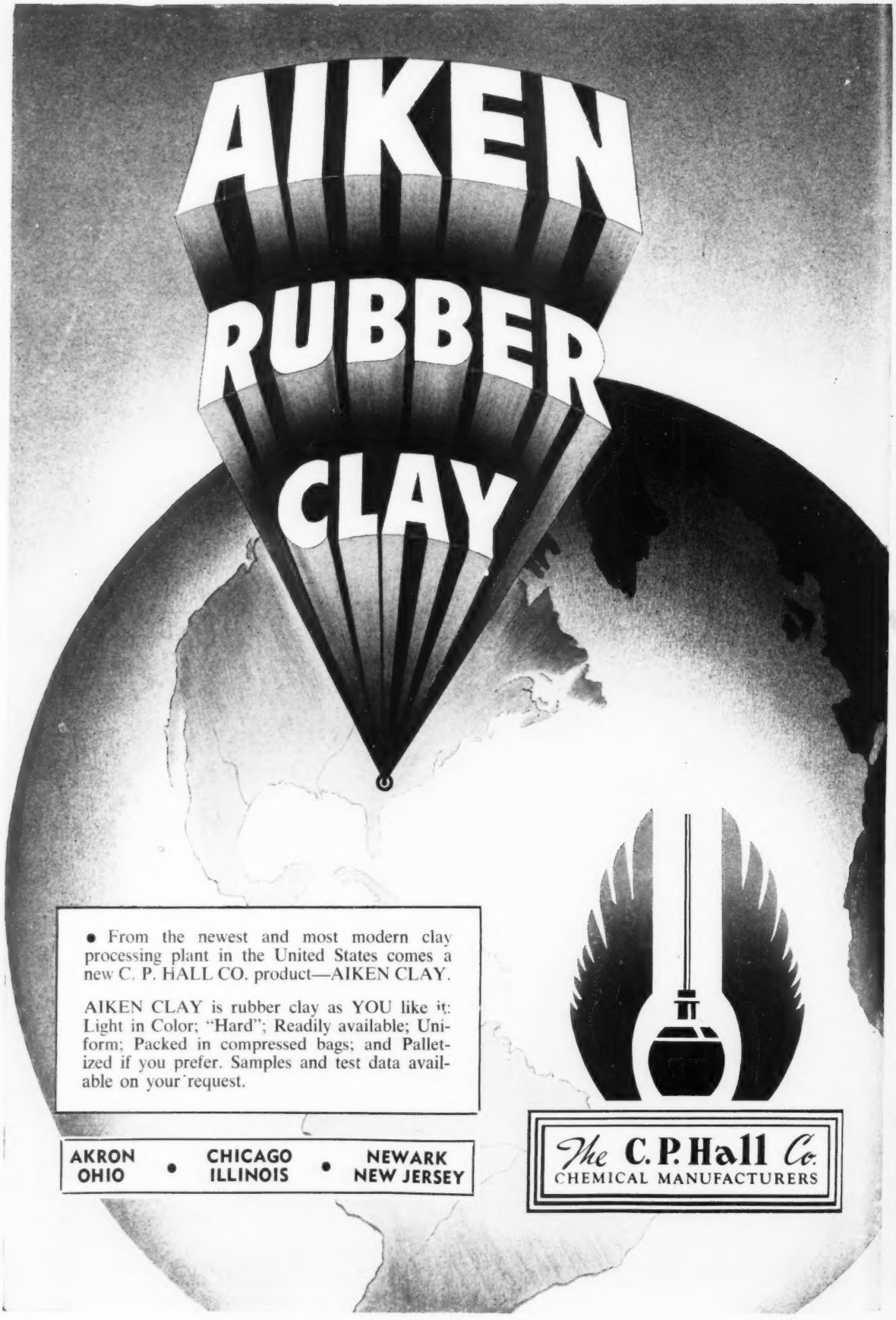
CHEMICAL GOODYEAR DIVISION

Chemigum, Pliobond, Pliolite, Plio-Tuf, Pliovic—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

Use-Proved Products — CHEMIGUM • PLIOBOND • PLIOLITE • PLIO-TUF • PLIOVIC • WING-CHEMICALS — The Finest Chemicals for Industry



TURNING OUT TOP QUALITY flooring is easier, faster, more profitable with PLIOVIC D880V — the new, dry blending polyvinyl chloride resin.


AIKEN
RUBBER
CLAY
• From the newest and most modern clay processing plant in the United States comes a new C. P. HALL CO. product—AIKEN CLAY.
AIKEN CLAY is rubber clay as YOU like it: Light in Color; "Hard"; Readily available; Uniform; Packed in compressed bags; and Palletized if you prefer. Samples and test data available on your request.
AKRON OHIO • CHICAGO ILLINOIS • NEWARK NEW JERSEY
The C. P. Hall Co.
CHEMICAL MANUFACTURERS

for the BEST...
in rubber and plastics
LOOK TO MUEHLSTEIN
For example — CRUDE RUBBER
For the best crude rubber connections in the world—look to Muehlstein! Muehlstein, with central offices in New York and London *and* direct agents in every corner of the globe provides a constant flow of information on the best crude rubber offerings. Simply contact any Muehlstein office.
You'll also find Muehlstein helpful on all types of Synthetic Rubber. A complete technical staff and laboratory facilities are available through home or regional offices.
And remember, other Muehlstein products include: REPROCESSED PLASTICS • SCRAP RUBBER HARD RUBBER DUST • SYNTHETIC RUBBER
MUEHLSTEIN & CO. INC.
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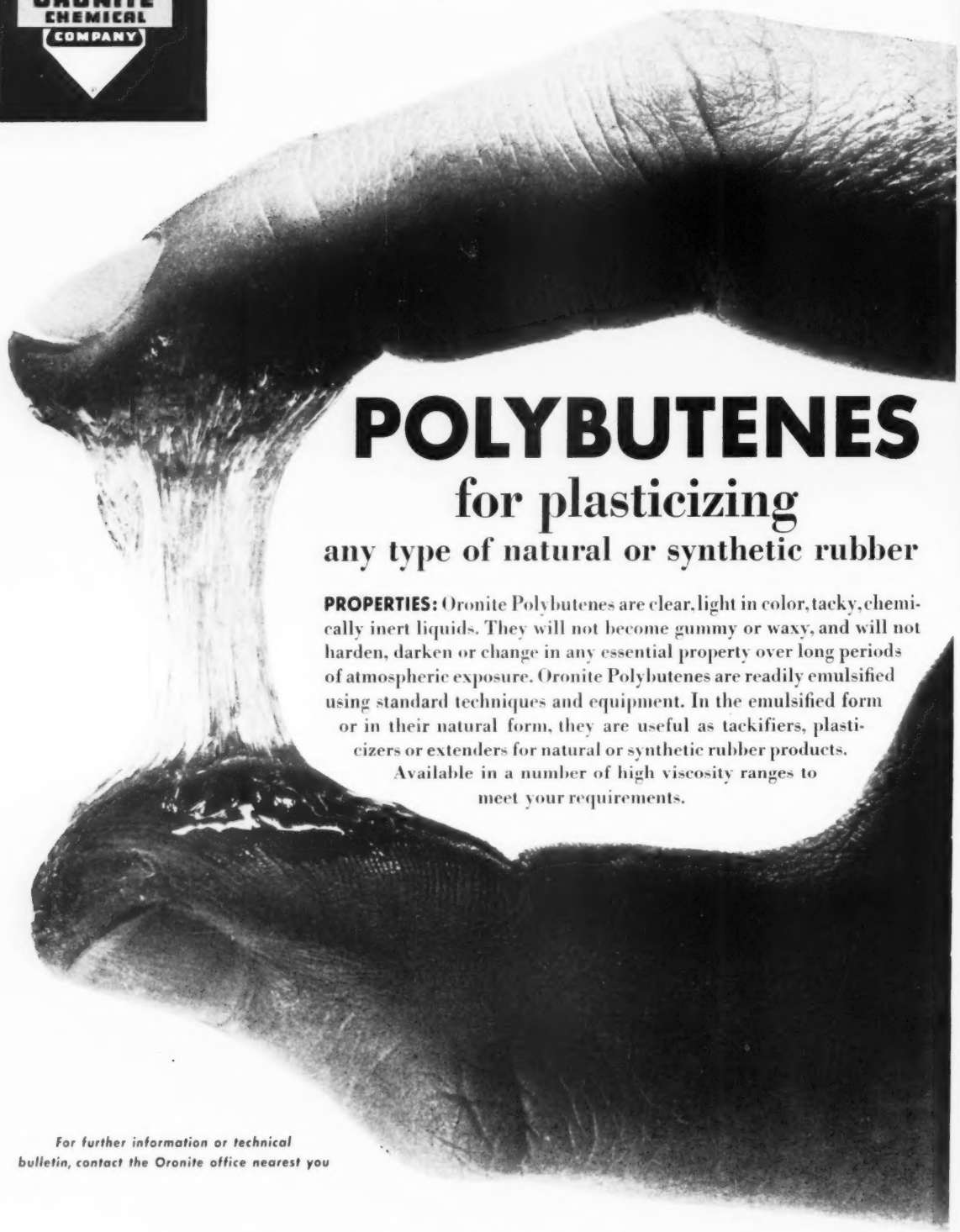
CRUDE RUBBER · SYNTHETIC RUBBER · SCRAP RUBBER · HARD RUBBER DUST · PLASTIC SCRAP
REGIONAL OFFICES: Akron · Chicago · Boston · Los Angeles · Memphis
WAREHOUSES: Akron · Chicago · Boston · Los Angeles · Jersey City

ORONITE CHEMICAL COMPANY

Original and Major source of supply!

(Oronite Polybutene was first produced and sold in 1935)



POLYBUTENES

for plasticizing

any type of natural or synthetic rubber

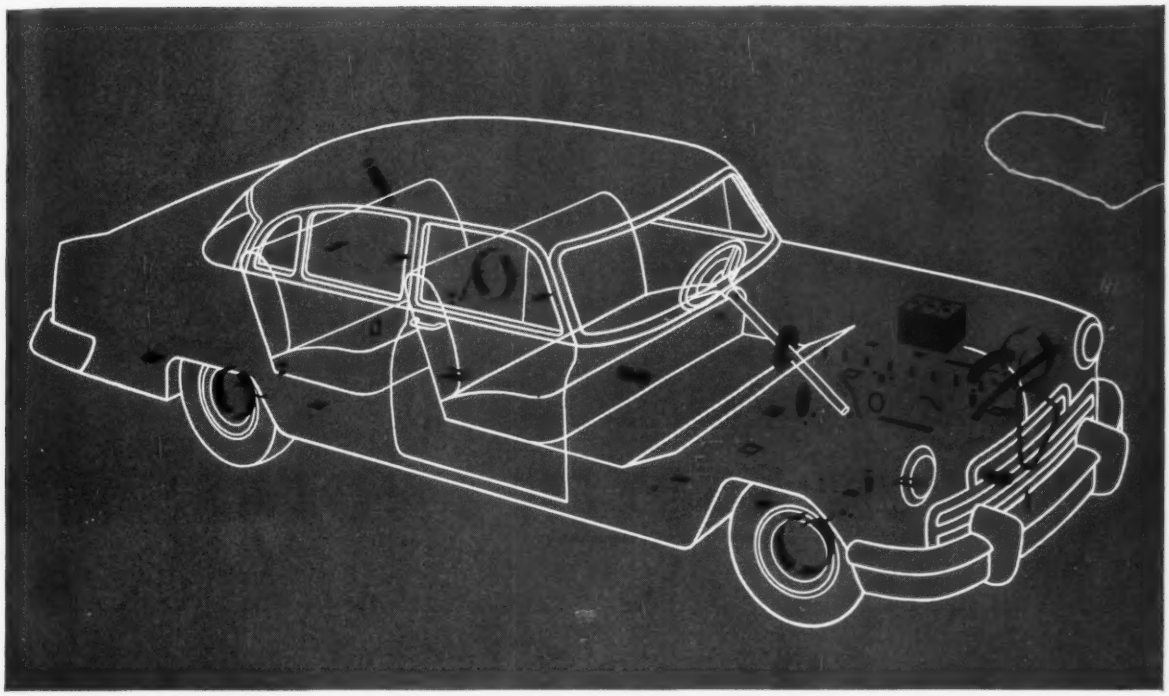
PROPERTIES: Oronite Polybutenes are clear, light in color, tacky, chemically inert liquids. They will not become gummy or waxy, and will not harden, darken or change in any essential property over long periods of atmospheric exposure. Oronite Polybutenes are readily emulsified using standard techniques and equipment. In the emulsified form or in their natural form, they are useful as tackifiers, plasticizers or extenders for natural or synthetic rubber products. Available in a number of high viscosity ranges to meet your requirements.

For further information or technical bulletin, contact the Oronite office nearest you

ORONITE CHEMICAL COMPANY

200 Bush Street, San Francisco 4, California • 714 West Olympic Boulevard, Los Angeles 15, California
30 Rockefeller Plaza, New York 20, New York • 600 South Michigan Avenue, Chicago 5, Illinois
Mercantile Securities Building, Dallas 1, Texas

UNDER THE HOOD and throughout the body of the average car, many parts molded or extruded of CHEMIGUM—the easiest-processing oil-resistant rubber—make the wheels turn longer, safer and smoother.



THE RUBBER

that really makes the wheels go round

ASK the average driver about automotive rubber and he'll first mention tires and tubes. Foamed rubber cushioning, floor mats, weather stripping and heater hose probably would be next. Actually there's much more to the role of rubber in automobiles.

All told, there are about 540 parts—238 pounds—of rubber in the average car. Take away the obvious items and there are still close to 500 parts vital to proper operation. Multiply that figure by the millions of units produced each year and you have big business. Tough business, too, since mass producers are so cost- and performance-conscious.

That's why CHEMIGUM—the first and finest nitrile rubber—is so often used to make so many automotive goods. Easier-handling bales, much easier processing, faster sulfurless cures, lower compounding costs, excellent aging and physical properties plus greater resistance to automotive oils and solvents are the reasons for choosing CHEMIGUM. For details write Goodyear, Chemical Division, Akron 16, Ohio.

CHEMICAL
GOODYEAR
DIVISION

Chemigum, Pliobond, Pliolite, Plio-Tuf, Pliovic—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

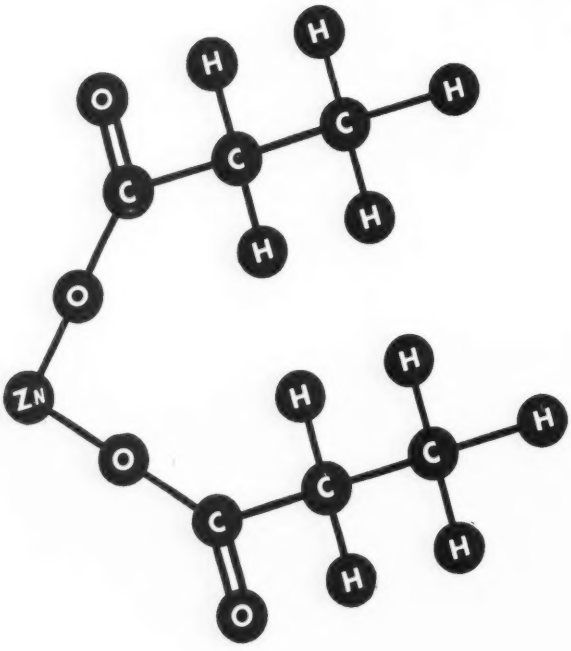
Use-Proved Products — CHEMIGUM • PLIOBOND • PLIOLITE • PLIO-TUF • PLIOVIC • WING-CHEMICALS — The Finest Chemicals for Industry

ACTIVATOR NEWS

HORSE HEAD PRODUCTS

A supplement to THE ACTIVATOR—the house organ issued by The New Jersey Zinc Company for over 15 years to aid the Rubber Industry in its use of Zinc Oxide.

FAVORED FORMULA FOR FASTER PROCESSING of ZINC OXIDE



Introduced to the Rubber Industry just a few years ago, this chemical (zinc propionate) is already the most favored processing and dispersion aid for zinc oxide.

It is available to the Rubber Industry in the form of a coating on zinc oxide, favorably modifying its physical properties without interfering with its activating characteristics.

Zinc propionate is formed as a coating on zinc oxide when the latter is treated with propionic acid at an elevated temperature. This coating forms around the individual particles, modifying their characteristics in these 3 ways:

1. **Prevents formation of aggregates—aids dispersion and reinforcement.**
2. **Provides faster wetting by rubber—cuts mixing time.**
3. **Adds plasticizing effect—speeds processing.**

These advantages, available only in Protox* zinc oxide, are proved by many manufacturers, as Protox is today the most widely used brand of zinc oxide. As one Banbury operator puts it, Protox-166 "streaks in" or "smears into the rubber" while untreated zinc oxide "spots in."

*U.S. Patents 2,303,329 and 2,303,330

THE NEW JERSEY ZINC COMPANY

Producers of Horse Head Zinc Pigments

... most used by rubber manufacturers since 1852

160 Front Street, New York 38, N. Y.

HORSE HEAD PRODUCTS

Shell Dutrex®

Plasticizers and Extenders for Rubber and Plastics—quality and economy combined

SHELL OIL COMPANY

50 WEST 50th STREET, NEW YORK 20, NEW YORK
100 BUSH STREET, SAN FRANCISCO 6, CALIFORNIA

SHELL

How to get **Better Polyesters**

at Low Cost

Can you mold a glass reinforced polyester that's strong enough to push over a brick wall and inexpensive enough to compete in the auto body market? Perhaps not today. But someday you may be called on to meet specifications almost that tough. And when you are, you'll probably be relying on a DIAMOND ALKALI Calcium Carbonate as a filler to help you get smoother surfaces, decreased shrinkage, improved wet strength and *lower cost.*

If you are not familiar with the DIAMOND's tailor-made precipitated calcium carbonates, here are brief descriptions:

Suspenso®—particle size about 5 microns.

Surfex®MM—Same as Suspenso, coated with 1% resin.

Multifex®MM—Uncoated, particle size about .06 microns.

Kalite®—Size about 1 micron, coated with 1% stearic acid.

For more information, specific formula suggestions and technical assistance, call your nearest DIAMOND Sales Office or write DIAMOND ALKALI Co., 300 Union Commerce Bldg., Cleveland 14, Ohio.

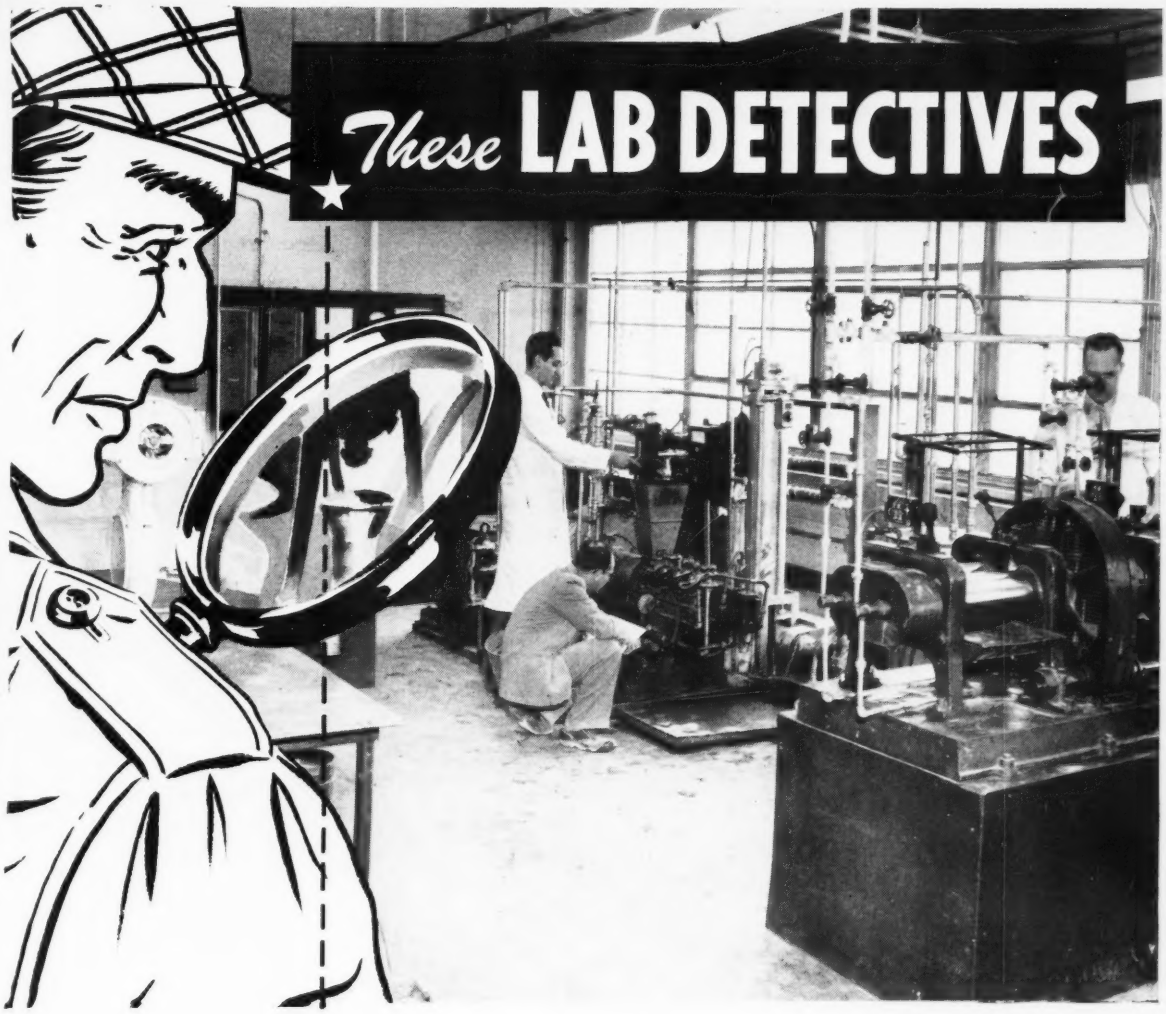
DIAMOND SALES OFFICES:
New York, Philadelphia, Pittsburgh, Cleveland, Cincinnati, Chicago, St. Louis, Memphis, Houston.

DIAMOND DISTRIBUTORS:
C. L. Duncan Co., San Francisco and Los Angeles; Van Waters and Rogers, Inc., Seattle and Portland, U.S.A.; Harrisons & Crosfield (Canada) Ltd.

DIAMOND ALKALI CHEMICALS ®

DIAMOND ALKALI COMPANY

CLEVELAND 14, OHIO



keep BUFFALO RECLAIMS UNIFORM

to guarantee CONSTANT quality of your products

The "who-done-its" have nothing on us! We have private eyes all over the place checking into every phase of our operation, delving into every batch of reclaimed rubber we process. They ask "why" and then ask "when" and then ask "what for"! Naturally, it costs money to maintain this staff of investigators and we could get along without them. BUT . . . we realize that it's good business to keep them working for us!

Working for us? Actually, they're working for you! Yes, you and all our other customers that have been buying long established, well-known Buffalo Reclaims for many years. These customers have learned to rely on the uniformity of these reclaims and their *constant* performance in their products.

We set up this force of quality-control "detectives" to make certain that we never fail to deliver EXACTLY the same properties in any given reclaim EVERY TIME. We think it a good idea . . . don't you?

Always keep reclaims in your formula . . . always look to Buffalo for the best!

U.S. RUBBER RECLAIMING COMPANY, INC.
P. O. BOX 365 BUFFALO 5, N. Y.

all in partnership with rubber...

but no two wires alike!

● Pictured above are four typical examples of the many special-purpose wires developed by National-Standard for wire-in-rubber products.

They do have one essential quality in common —a highly developed affinity for adhesion with rubber. But beyond that, each has a different job to do . . . and is painstakingly engineered to do it . . . effectively!

For years National-Standard has specialized in improving the behavior of wire in rubber—digging into all the intricacies of application, fabrication, finish, corrosion, strength, elongation, adhesion and innumerable details you might never bother with.

Main reason for all this research, this "groundwork", is to help you improve your products, increase production, conserve materials and cut costs! Perhaps you now face *new* defense production problems involving wire. Remember, National-Standard service is always at *your* service.

NS NATIONAL-STANDARD Company NILES, MICHIGAN

DIVISIONS OF NATIONAL-STANDARD CO.

ATHENIA STEEL	*Clifton, N. J.*	Flat, High Carbon, Cold Rolled Spring Steel
NATIONAL-STANDARD	*Niles, Mich.*	Tire Wire, Stainless, Fabricated Braids and Tape
REYNOLDS WIRE	*Dixon, Illinois*	Industrial Wire Cloth
WAGNER LITHO MACHINERY	*Jersey City, N. J.*	Metal Decorating Equipment
WORCESTER WIRE WORKS	*Worcester, Mass.*	Round and Shaped Steel Wire, Small Sizes

Announcing

2 NEW
additions in
the FAMOUS

TY·PLY®

RUBBER-TO-METAL
ADHESIVE FAMILY

TY-PLY "UP" NEW UNIVERSAL PRIMER

TY-PLY "RC" RUBBER COVER CEMENT

Exceptionally suitable for natural rubber stocks (both normal and low-sulfur), standard and cold-polymerized GR-S's, polybutadiene, oil-modified GR-S, arctic-type GR-S and natural GR-S blends. Both adhesives have excellent shelf and working stability; are insensitive to weather or ozone conditions; and work well over a wide range of curing temperatures.

TY·PLY (Q) or (3640) for bonding Natural, GR-S, and Butyl

TY·PLY (BN) for bonding N-types

TY·PLY (S) for bonding Neoprene

TY·PLY will adhere most vulcanized rubber compounds to almost any clean metal surface

Marbon

MARBON CORP.

GARY, INDIANA

SUBSIDIARY OF BORG-WARNER

TY·PLY has stood the test of time . . . since '39

all dolled up with Titanox®

Cuddly dolls, the kind every little girl wants, are most warm and appealing when the rubber or plastic has the realistic coloration provided by TITANOX white pigments. Proper pigmentation adds tremendously to the sales appeal of any rubber product, from dolls to white wall tires.

TITANOX titanium dioxide pigments are compatible with all types of rubber and plastics. These strongest of white pigments add quality by imparting whiteness and maximum brightness and opacity to white or tinted products while maintaining natural strength and life.

Consult with our Technical Service Department for the solution to any rubber or plastic pigmentation problem you may have. Titanium Pigment Corporation, 111 Broadway, New York 6, N. Y.; Atlanta 2; Boston 6; Chicago 3; Cleveland 15; Los Angeles 22; Philadelphia 3; Pittsburgh 12; Portland 9, Ore.; San Francisco 7. In Canada: Canadian Titanium Pigments Limited, Montreal 2; Toronto 1.

®TITANOX

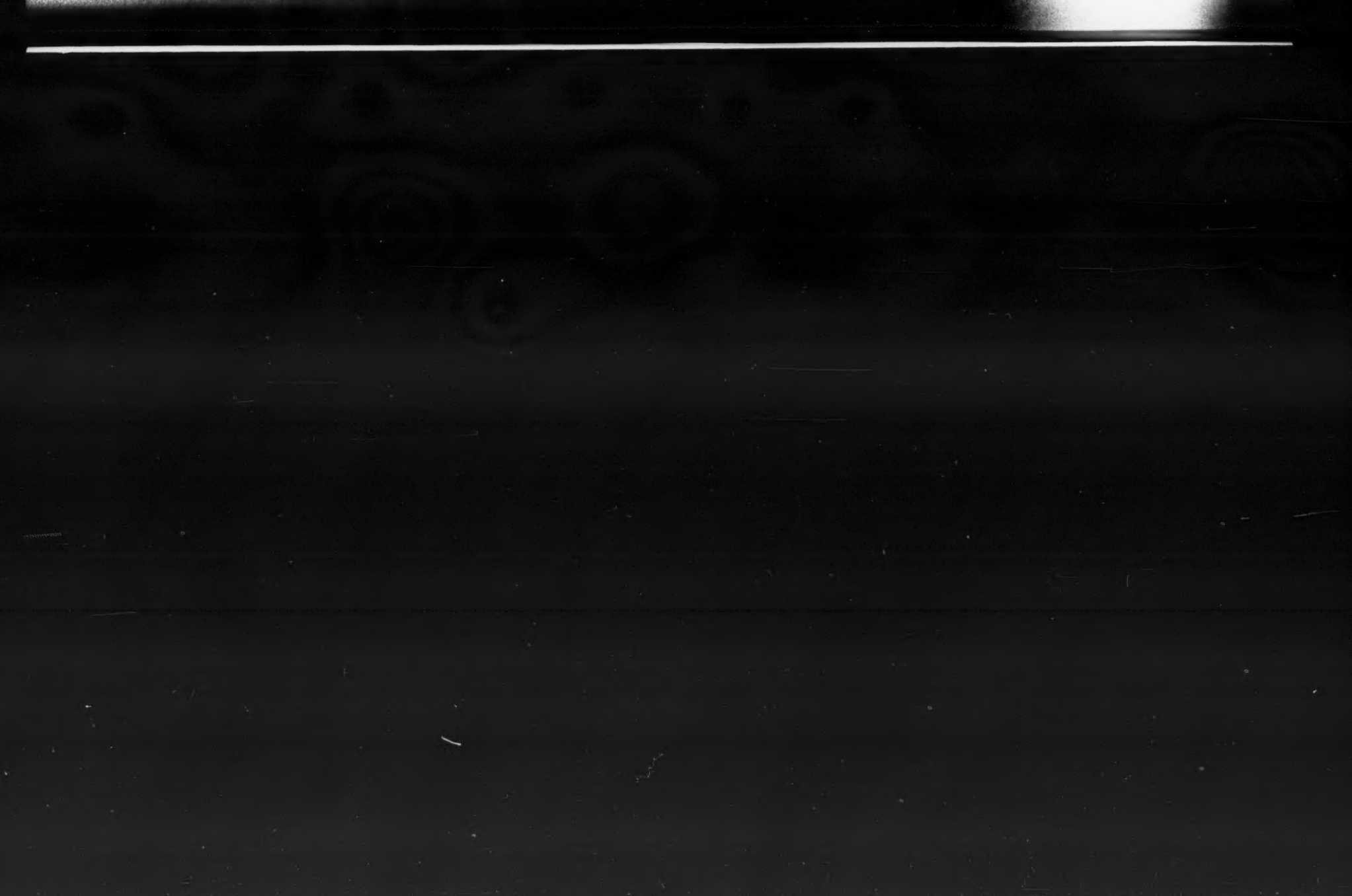
the brightest name in pigments

2239

TITANIUM PIGMENT CORPORATION

Subsidiary of NATIONAL LEAD COMPANY

ORLD



makers of... Quality Carbon Blacks

When talking about carbon blacks — no matter where — the thoughts invariably go to UNITED. The reason is simple enough: UNITED blacks have a long-established record for top notch quality, consistent uniformity and pleasing performance.

The widely known Dixiedensed (channel) and Dixie (furnace) brands made from gas or oil represent a complete range of reinforcement.

Naturally, leaders everywhere use UNITED blacks. Follow the leaders.

UNITED'S technical literature, a valuable reference for the entire rubber industry, will be sent free upon request to our Research Division.

UNITED CARBON COMPANY, INC.

CHARLESTON 27, WEST VIRGINIA

NEW YORK • AKRON • CHICAGO • BOSTON • MEMPHIS

Dixie 70. A remarkable carbon black which makes tires much stronger and keeps them running much longer and with less cracking. A natural for mileage tires.

Dixie 70. A super black, oil base and furnace made, that boasts of the particle fineness and surface nature that tires must have to withstand fast and heavy driving.

Dixie 70. The black that is in the front for performance in synthetic and crude rubber. Easy to mix, excellent for processing and tops for reinforcement.

Specify UNITED blacks for gratifying results.

UNITED CARBON COMPANY, INC.

CHARLESTON 27, WEST VIRGINIA

NEW YORK AKRON CHICAGO BOSTON MEMPHIS

The most solvent resistant rubber

Thiokol®

SYNTHETIC RUBBER TYPE FA

for paint spray, gasoline, aromatic fuel and solvent hose

"Thiokol" synthetic rubber has long been recognized as the outstanding solvent resistant rubber. This property has led to its wide use in the fabrication of rubber goods that must withstand the deteriorating effects of lacquer, paint thinners, aromatic fuels, and a wide range of other solvents.

The following formulation illustrates a typical compound used for hose liners:

HOSE LINER RECIPE

"Thiokol" FA	100.0
Zinc Oxide	10.0
SRF Black	60.0
Stearic Acid	0.5
B.T.D.S. (1)	0.4
D.P.G.	0.1
NA-22	0.1
Neoprene Type W Masterbatch	29.0

(1) Benzothiazyl Disulfide

Neoprene Type W Masterbatch

"Neoprene" W	100.0
E.L. Cal. Mag.	4.0
S.R.F. Black	55.0
Stearic Acid	0.5
Zinc Oxide	5.0

The Neoprene W masterbatch is added at the end of the mix and thoroughly blended with the base compound.

PHYSICAL PROPERTIES

	Original Properties	Aged 48 hours at 80° F. in SR-6 Fuel (Dried 2 hr.)		Volume Swell (24 hrs. at 80°F.)	
Cure	40′/298°F.	40′/298°F.	% Loss	Distilled Water	4%
300% Stress	1375	—	—	Ethyl Acetate	24
Tensile	1375	900	34.5	Acetone	18
Elongation	300	230	23.0	SR-6	20
Durometer	74	—	—	SR-10	4

Because of the exceptional solvent resistance of "Thiokol" type FA, small percentages of synthetic elastomers can be added as processing aids without appreciably reducing its solvent resistance.

For additional technical information and samples write:

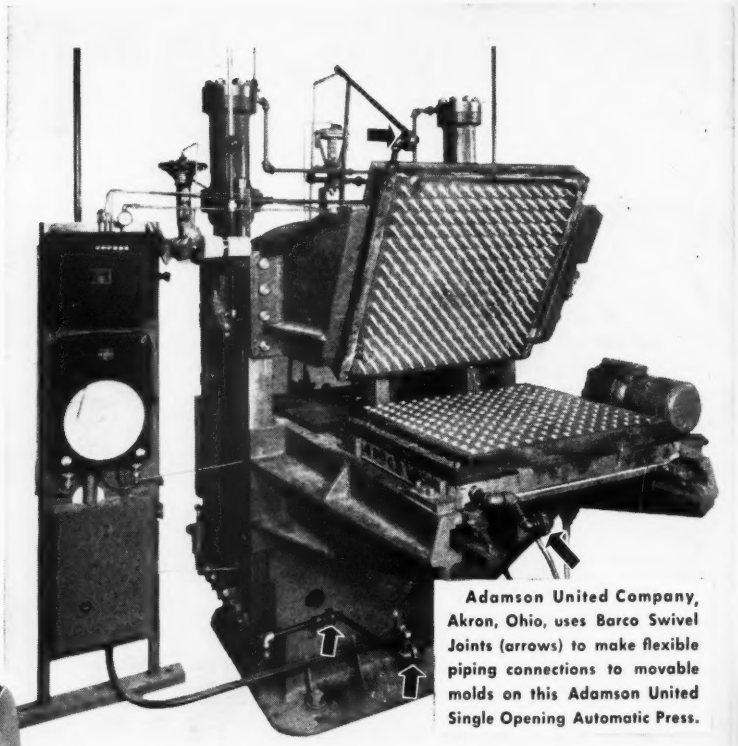
This information is believed to be accurate. However, no warranty is expressed or implied regarding the accuracy of these data, or the use of this product.

Thiokol® Chemical Corporation

784 NORTH CLINTON AVENUE • TRENTON 7, NEW JERSEY

In Canada: Naugatuck Chemicals Division, Dominion Rubber Company, Elmira, Ontario

EVERY ENGINEER *will want a copy of this* NEW BULLETIN



Adamson United Company, Akron, Ohio, uses Barco Swivel Joints (arrows) to make flexible piping connections to movable molds on this Adamson United Single Opening Automatic Press.

IT'S easy to get the right answer for even your most special steam, air, or hydraulic *piping jobs* when you use this new engineering catalog on BARCO SWIVEL JOINTS. It is complete with pictures and diagrams showing correct application and contains all specification data for *improved* Barco Swivel Joints:

- Leakproof! Perfect Sealing—Hot or Cold.
- No Binding, Low Torque! Trouble-free.
- Self-Aligning! Simplifies Installation.
- No Lubrication Required! Easy Maintenance.
- Economical! Wide Choice of Sizes and Styles.

SEND FOR A COPY OF NEW CATALOG NO. 265A AND INSTALLATION DRAWING 10-52004

IMPROVED

BARCO *Swivel Joints*

FOR MOVABLE PLATEN MOLDING PRESSES

DEPENDABLE, TROUBLE-FREE PERFORMANCE — time after time — has been the one big reason for using self-aligning Barco Swivel Joints in flexible piping connections and dog-legs on movable platen molding presses used in the rubber industry. And now Barco offers even *better* performance and service, not only for new uses, but for thousands of existing installations.

The ANSWER is Barco's new, chemically inert No. 11 CTS gasket. No other material is as amazingly long wearing and versatile. Even under most adverse conditions, joints maintain their seal, hot or cold, working or idle — with lower torque and no lubrication required. Natural operating action keeps the hemispherical ball of the joint lapped to a perfect fit.

Get this *advanced performance* in new Barco Swivel Joints! Send for complete information on MODERNIZING old joints!

BARCO *Manufacturing Co.*

510J Hough Street, Barrington, Illinois

In Canada: The Holden Co., Ltd.

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints

RELIABLE ZINC OXIDES

AZO-ZZZ-44 and AZO-ZZZ-55 assure good dispersion and easy processing because of their uniform particle size and absence of extreme fines. With AZO-ZZZ-11, 22, 33, (Acicular types) and special grades, a complete range of zinc oxides is offered for every rubber requirement.

A RELIABLE SOURCE

American Zinc assures an uninterrupted supply of zinc oxide. Recent discovery and development of a new, large ore body, added to previous American Zinc reserves, provides sufficient ore to last many years at the current rate of production.

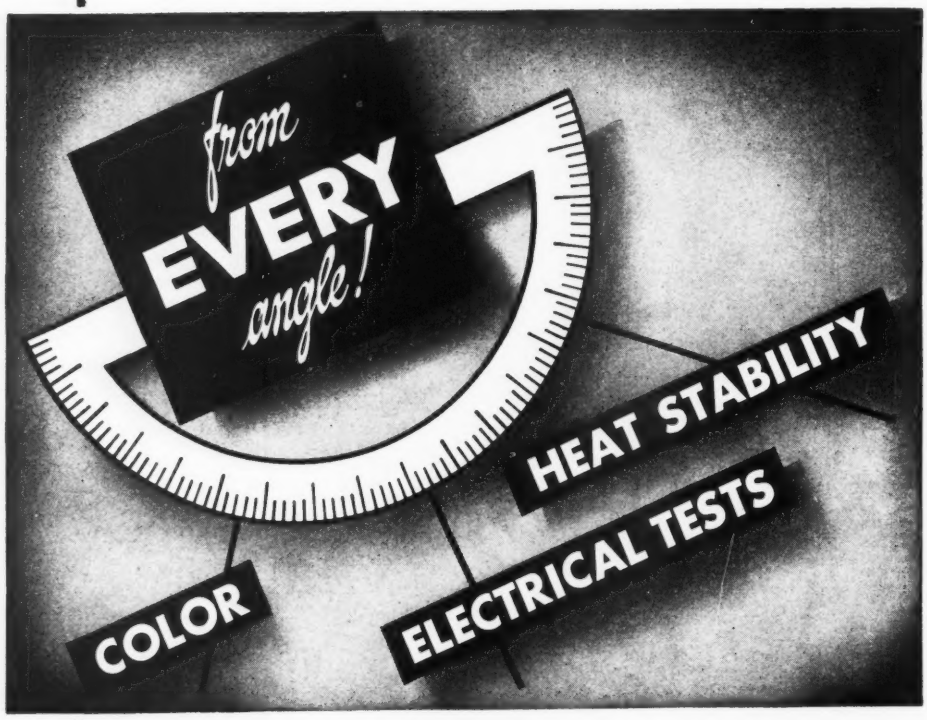
AZO **ZZZ-44**
ZZZ-55

AMERICAN ZINC SALES COMPANY

distributors for

AMERICAN ZINC, LEAD & SMELTING COMPANY

COLUMBUS, OHIO • CHICAGO • ST LOUIS • NEW YORK



PIGMENT NO. 33

for Compounding

VINYLS AND SYNTHETIC RUBBER

Sample and technical data sent promptly on request

SOUTHERN CLAYS, Inc.

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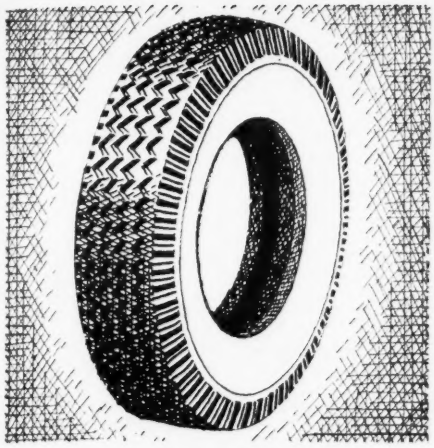
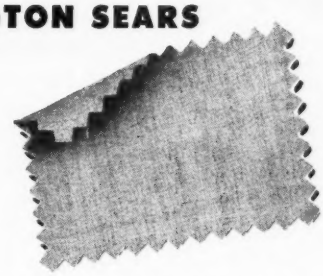
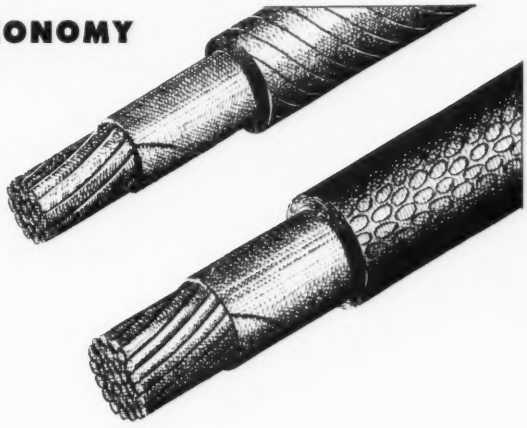


Woven for strength and abrasion resistance, chafer duck is typical of Wellington Sears reinforcing fabrics.

Wellington Sears rubber footwear fabrics include sturdy, economical and easily adhesive enameling duck for tennis and gym shoes and other rubber footwear.

YOU GET UNIFORM QUALITY AND ECONOMY WITH WELLINGTON SEARS COLUMBUS SHEETING



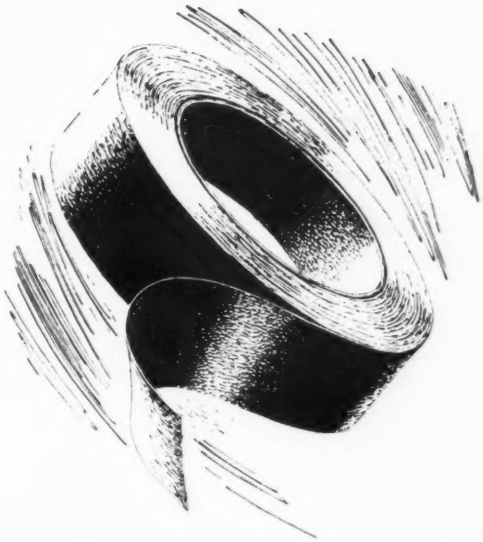


Matching quality, yard after yard, is the basis for Columbus sheeting's long-standing reputation in rubber fabrication. Lightweight and economical, it is carefully woven to yield an absolute minimum of rubberizing process rejects.

These sheetings are made 40 to 120 inches wide in weights from 2 to 5 ounces per square yard. For submarine and other cable wrapping . . . friction tape . . . heavy duty raincoats . . . hospital sheeting . . . Columbus sheeting has versatility to equal its uniformity.

Other cotton, synthetic, and blended fabrics available from Wellington Sears for coating, specialties, and mechanical rubber goods are listed at right. If it's a rubber-and-fabric problem, talk it over with Wellington Sears.

Write for your free copy of "Modern Textiles for Industry" which includes pertinent information on rubber applications. Address: Wellington Sears Co., Dept. K-6, 65 Worth St., N. Y. 13.



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Belting duck
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Single and plied-yarn chafers
Sheeting
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Balloon cloth
Nylon, high tenacity rayon, other synthetics and combinations.

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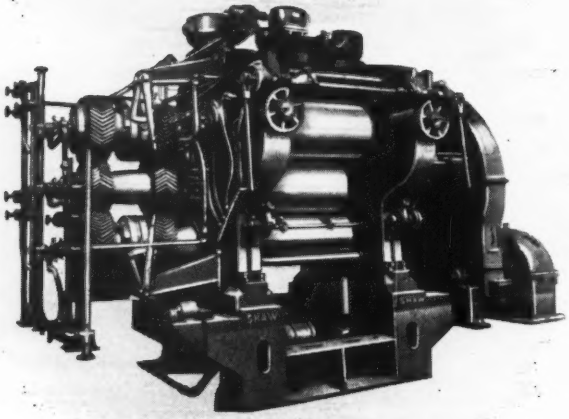
There is a range of SHAW *precision Calenders*



Designed for production efficiency, economy and reliability, Shaw Precision Calenders are made with two to four bowls for all types of synthetic and rubber materials. Refinements of design include bored and drilled rolls for heating and cooling, flood lubrication to the roll bearings and hydraulically operated zero clearance.

SHAW PRECISION CALENDERS

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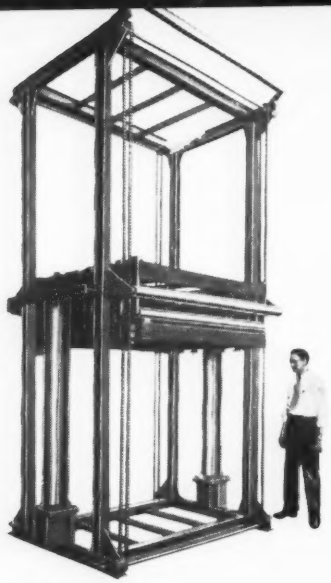
Rubber..... AND Plastics

CALENDER ACCESSORY EQUIPMENT



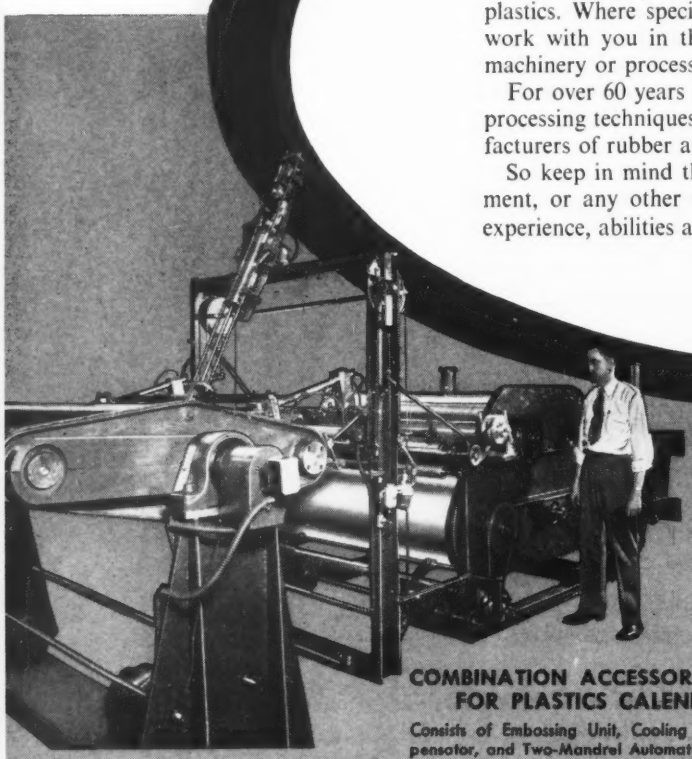
FESTOONER

A double-acting unit for handling various types of tire cord. It is used in conjunction with high-speed precision calendering equipment to store fabric while the let-offs or windups are stopped for roll changes.

Adamson not only engineers and builds a complete line of standard and special calenders, but in addition can supply all types of Calendering Accessory Equipment required for the continuous processing of rubber o plastics. Where special equipment is needed, our engineers are available to work with you in the development, design and construction of the right machinery or process to meet your requirement.

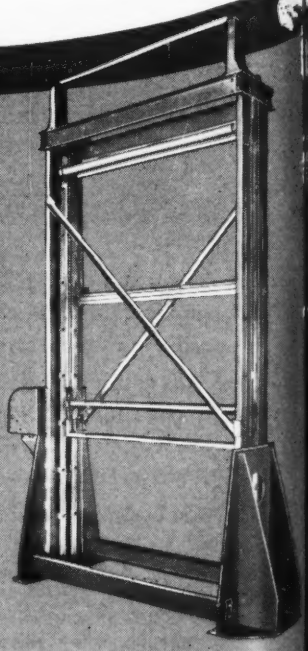
For over 60 years Adamson has pioneered in the advancement of rubber processing techniques, and today is a major supplier of equipment to manufacturers of rubber and plastics products the world over.

So keep in mind that whether it's Calenders, Calender Accessory Equipment, or any other type of rubber or plastics processing machinery, our experience, abilities and manufacturing facilities are at your service.



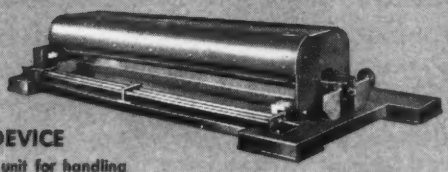
SINGLE ROLL COMPENSATOR STAND

For coordinating the speed of various elements in a calender train.



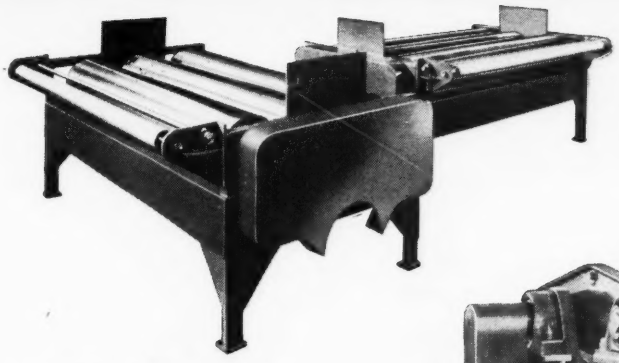
COMBINATION ACCESSORY TRAIN FOR PLASTICS CALENDER

Consists of Embossing Unit, Cooling Drum Stand, Compensator, and Two-Mandrel Automatic Turret Windup.



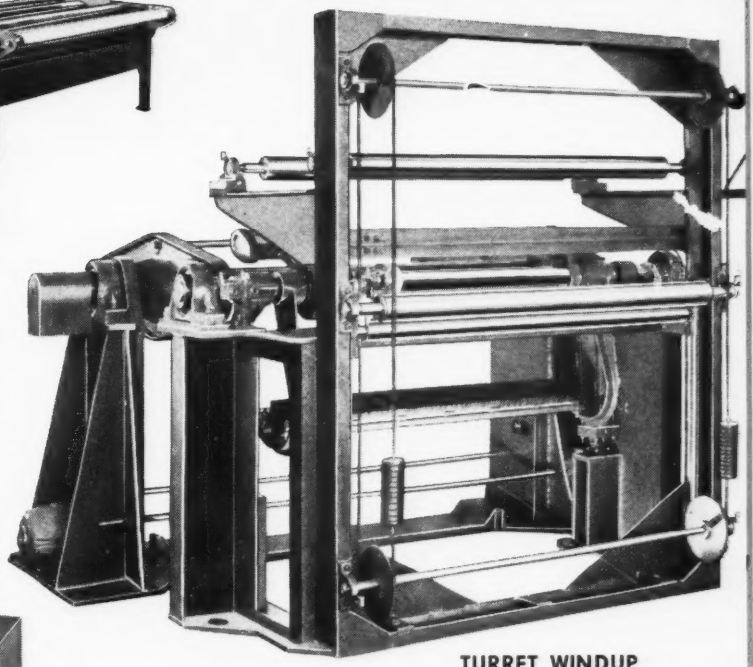
FABRIC CENTERING DEVICE

A rugged, 3-roll motor-driven unit for handling fire cord prior to its entry into the calender.



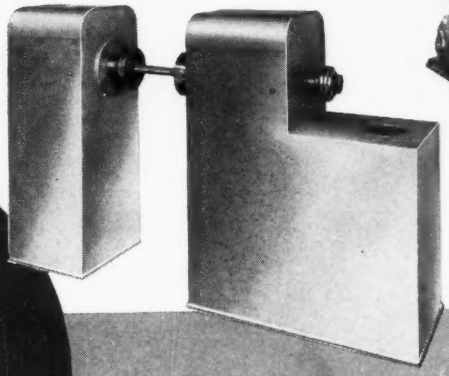
SURFACE WINDUP UNITS

Simple, conventional, drum-type windups for handling plastic film, plastic sheeting and coated fabrics.



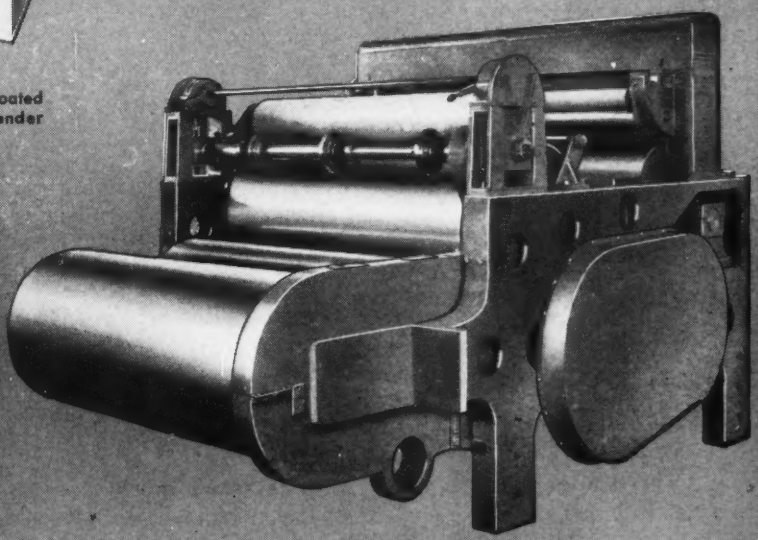
TURRET WINDUP

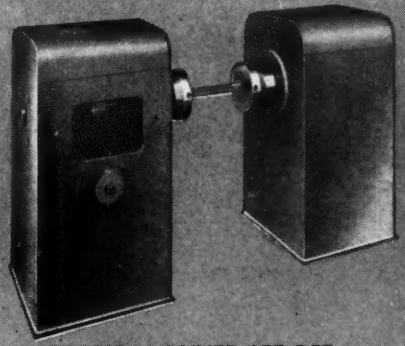
A special, center-drive windup designed specifically to wind very thin plastic film under accurately controlled, minimum tension. Equipment includes Two-Mandrel Turret, Automatic Counter and Cutting Device.



SIMPLE WINDUP STAND

Motor driven type for winding of coated fabric. Floor mounted type. Calender mounted units are also available.





FABRIC and LINER LET-OFF

Friction type, used in handling fabric for 3-roll universal calenders or for 4-roll double-coating calenders.

SPECIAL COMBINATION COOLING AND CUTTING DEVICE for RIGID PLASTIC SHEETING. Used with 4-roll calenders, with gear ratio changing equipment, to modify length of cut. Trim chopping device included.

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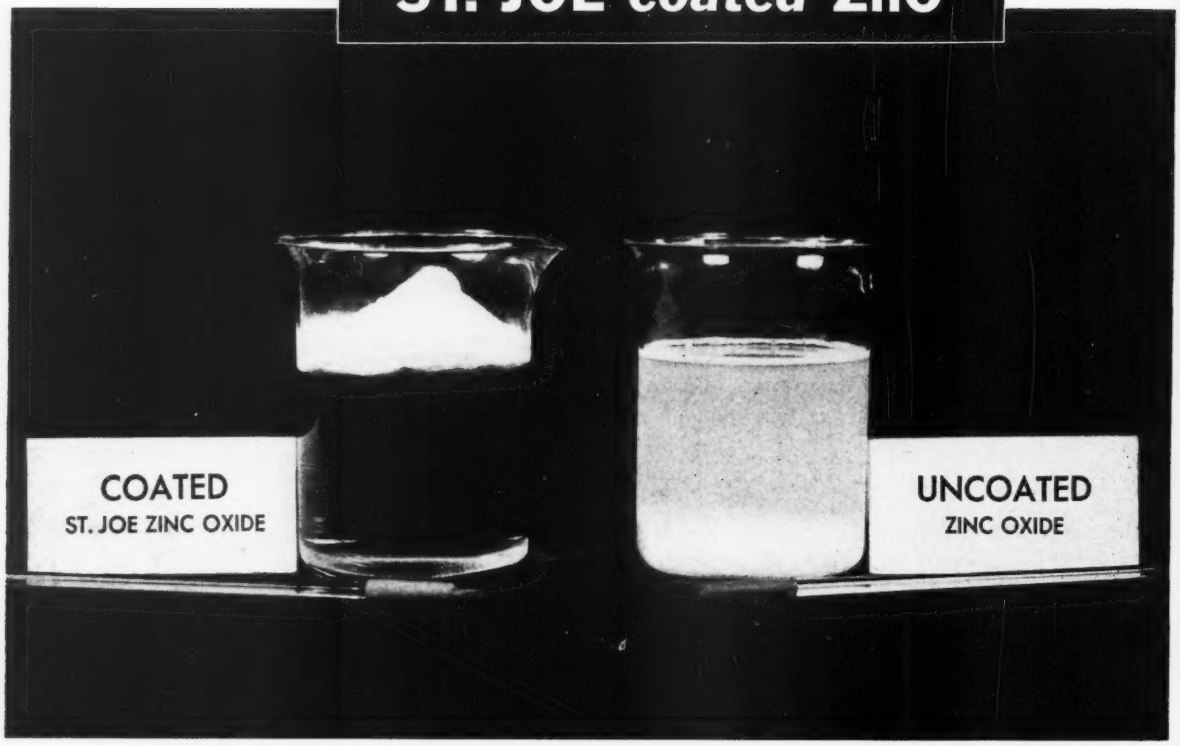

The photograph above graphically illustrates the hydrophobic nature of the surface treatment given all St. Joe coated Zinc Oxides which indefinitely resist wetting when placed in contact with water. This unique property of St. Joe coated Zinc Oxides guarantees to the consumer maximum resistance to moisture absorption during storage. Other factory-proved advantages of St. Joe coated Zinc Oxides are:

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⑤ *Lower mixing temperature*
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(LIQUID CONCENTRATE)

THE ALL PURPOSE EXTERNAL LUBRICANT

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DOES NOT INTERFERE WITH TACK OR KNIT

Prevents adhesion of hot rubber slabs when piled . . . banishes dust nuisance by replacing soapstone or talc . . . prevents sticking during cure of extrusions and flat pan coiled tubing . . . excellent release agent for molds, mandrels, air bags, belt drums . . . equally satisfactory for washing and finishing inner tubes; imparts satiny finish . . . greatly aids in the processing of insulated wire and cable. The Production Departments and Laboratories of many rubber manufacturers, through years of using GLYCERIZED, give ample proof of its outstanding qualities as a lubricant for natural, synthetic and reclaimed stocks.

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1 drum makes up to 50 drums of working solution.

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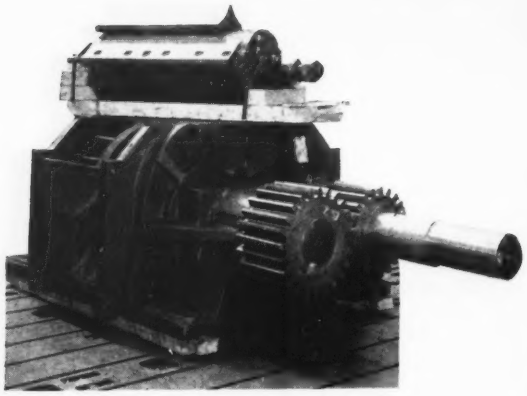

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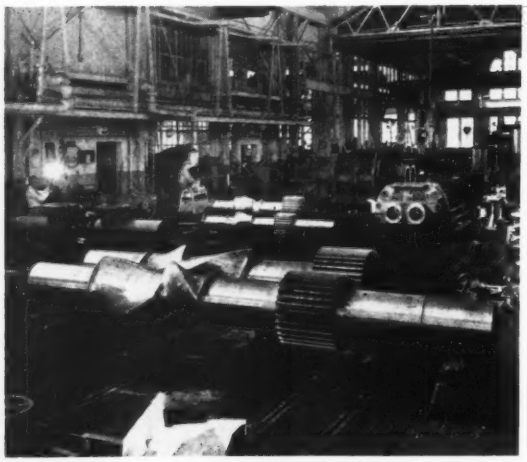

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. . . that your worn Banbury body will be returned to your line as good as new. Rotors, side jackets, rings, bearings, end frames, thrust nuts, door top, connecting gears—ALL are worked over carefully by skilled men. Each worn part is built up to its original size and contour and all wearing surfaces thoroughly hard-surfaced. New parts are used where necessary.

For 21 consecutive years—since 1933—we have specialized exclusively on Banbury repairing. Our plant facilities are the finest possible, and we can fabricate any Banbury parts needed.

You can INTERCHANGE your present Banbury body for one of ours, completely rebuilt, or you can use our "PRE-PLAN" method to have your body rebuilt and returned. Either way YOU SAVE valuable weeks of production time. We have ready for immediate interchange rebuilt bodies in sizes 3 and 9, each with door and cylinder.

Parts For Immediate Shipment

1 pr. NEW #9 Banbury rotors.
1 pr. #27 Banbury steel rotors, rebuilt.
1 pr. #27 Banbury side jackets, rebuilt.
1 #27 bull gear, pinion and pinion shaft.
Also many other miscellaneous parts.

Give us a call. It will cost you nothing to have an estimate. One of our engineers will visit your plant and inspect your installation at your request.

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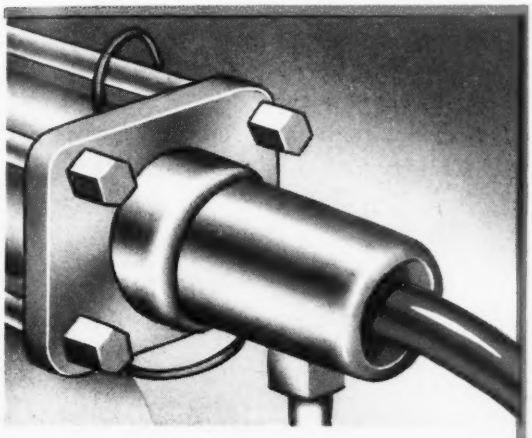

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PASTE - -

A "single package" stabilizer for high heat resistance plus good light stability . . . Contains cadmium and barium components and synergized chelating agent. Disperses easily in dry pre-blends, solutions and dispersions.

LIQUID - -

A synergized chelating agent.

POWDER - -

A metal bearing component of STABELAN HR paste.

STABELAN HR has been used with marked success in stabilizing all types of Vinyls containing organic and inorganic pigments.

For Excellent Light and Good Heat Stability

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STABELAN E — Paste — Provides excellent stabilizing for ultra-violet and outdoor aging . . . It gives good light fastness and heat stability. Heat stability and transparency may be improved when Stabelan E is used with Stabelan HR Liquid. Gives films that do not "blush" or absorb water . . . It is compatible with all tested pigments — even organic reds hold their hue and age well . . . It does not cause plating on rolls.

Write for complete data on these materials.

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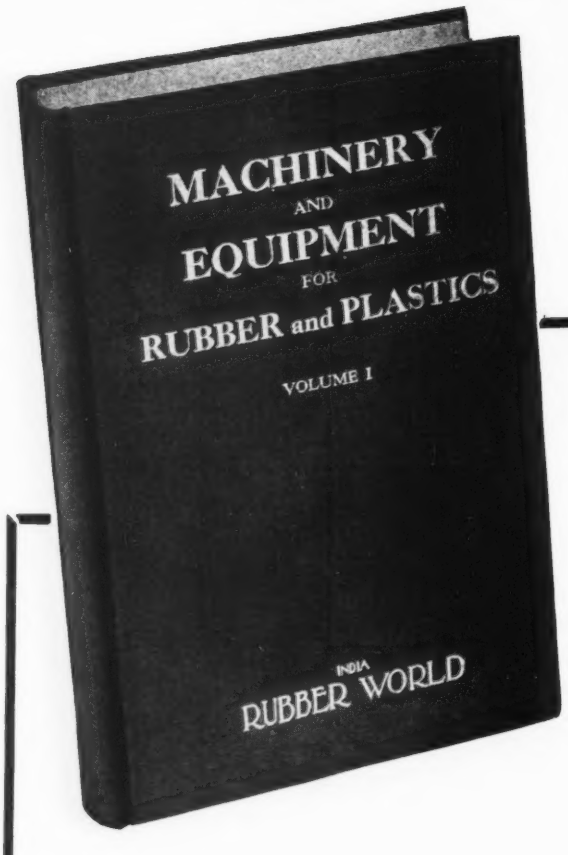

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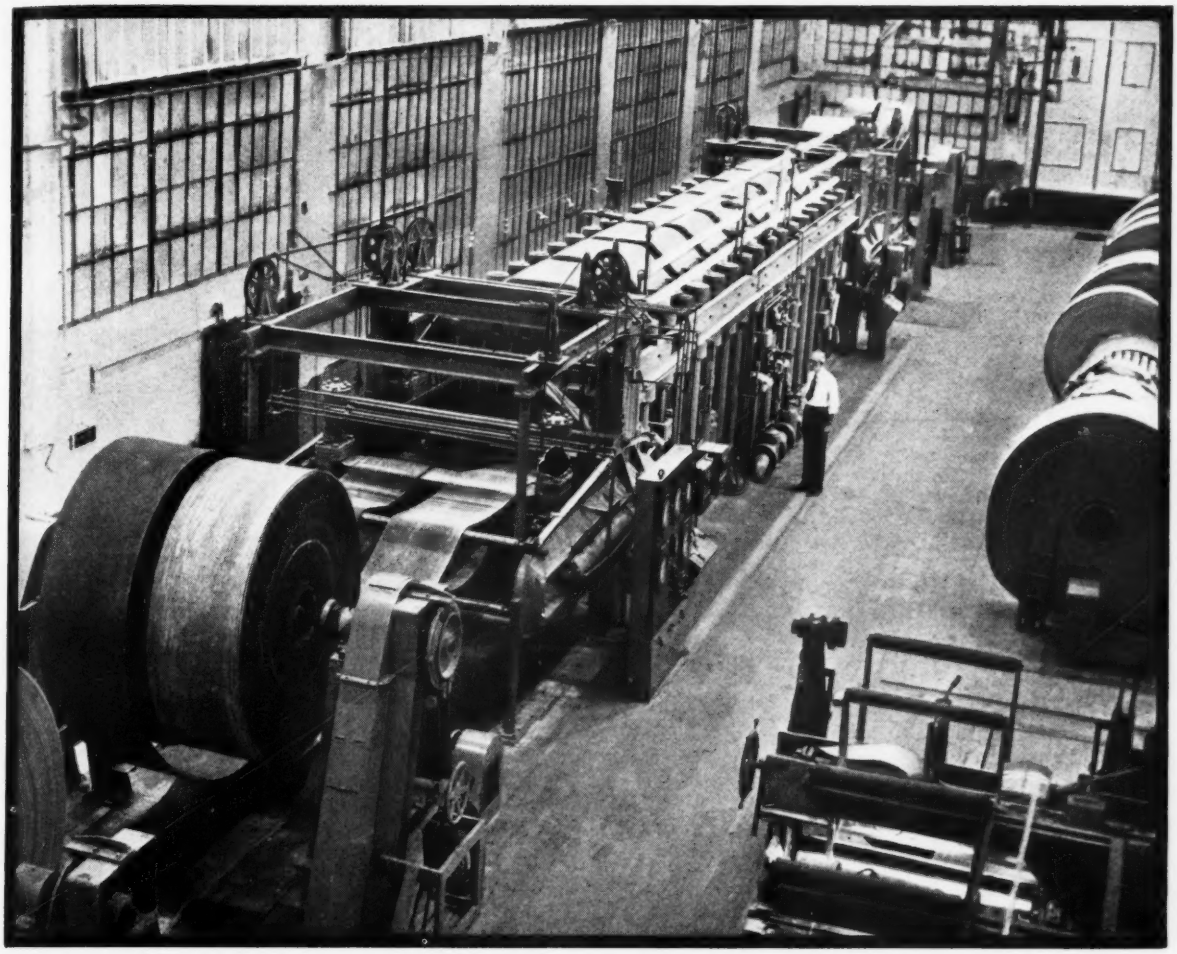

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to industry's demand for larger conveyor belts

Installed in the Goodyear Tire & Rubber Company's plant at Akron, Ohio, is the world's largest capacity belt press. Designed and built by Farrel-Birmingham, it is capable of vulcanizing conveyor belts 72 inches wide, or one-third as wide as the standard two-lane highway.

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This addition to Goodyear's flat-belt production capacity is a well-timed answer to the increasing demand for belts with greater pay-load capacity.

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FB-920

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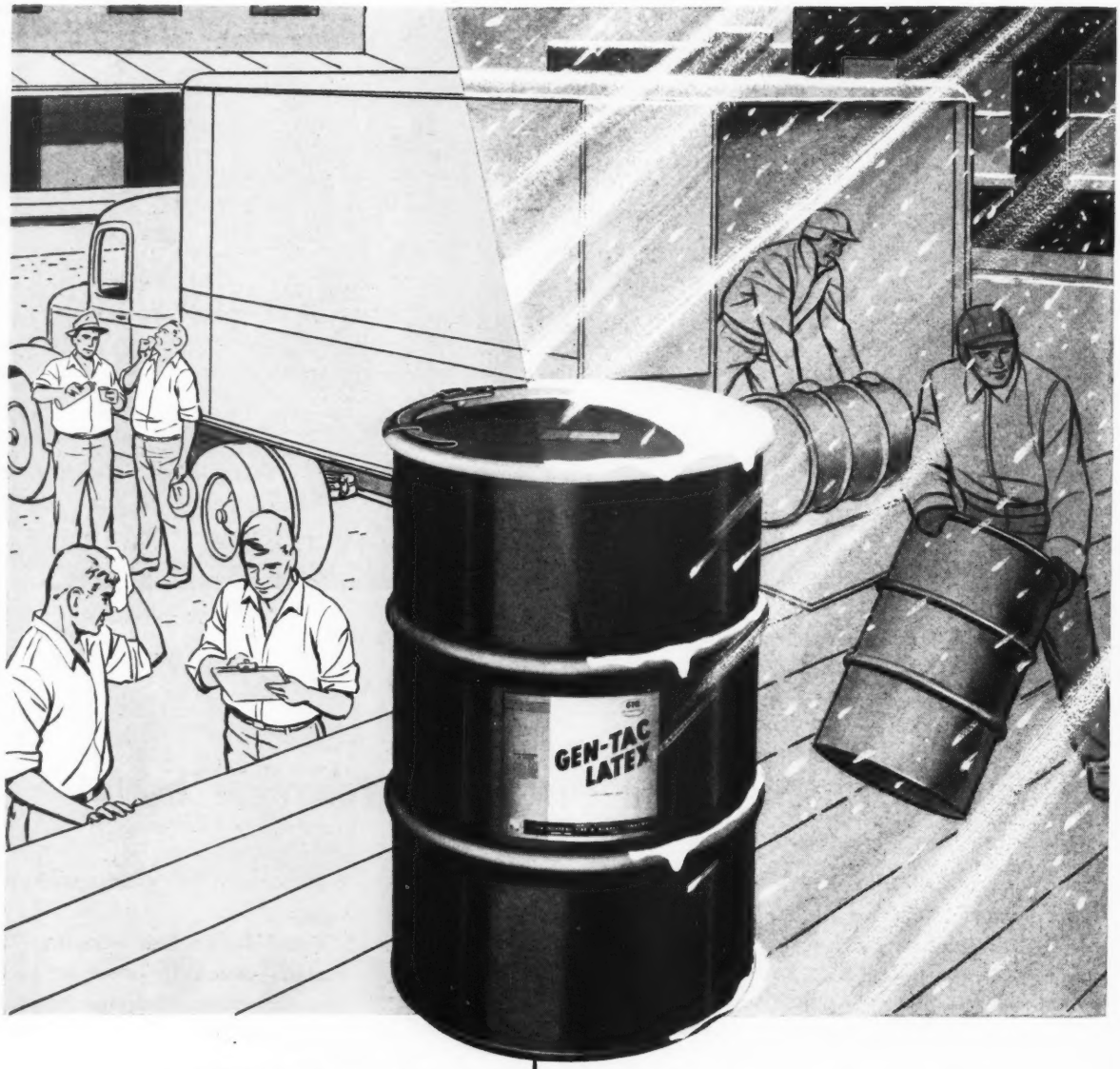

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RW-8-54

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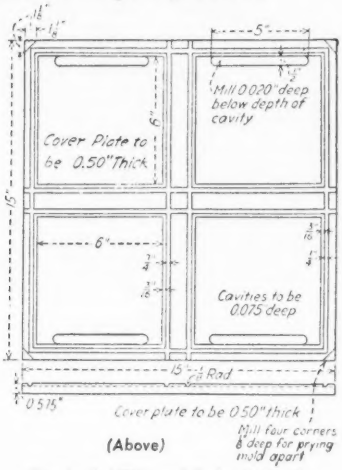
Shown here are but a few of the many types of rubber working equipment available. Please submit your problem.


Mill 0.020" deep below depth of cavity
Cover Plate to be 0.50" Thick
Cavities to be 0.075 deep
Cover plate to be 0.50" thick
Mill four corners 8 deep for prying mold apart

(Above) Standard ASTM and Federal dies for cutting test tensile and tear strength samples, and dies for slab curing carried in stock. Write for catalog.

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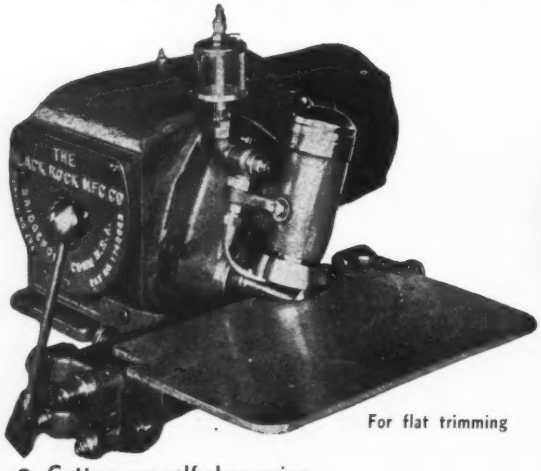
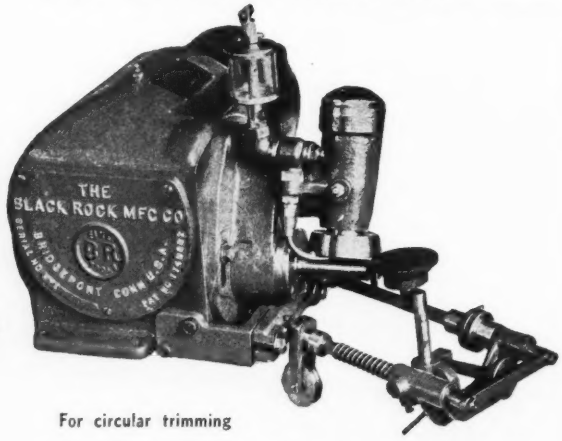
. . . with a BLACK ROCK 4TA



For flat trimming



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Age Rite White	0.5
Zinc Oxide	15
Whiting (Water Ground)	50
Burgess Iceberg Pigment	**15**
Burgess Pigment #20	**60**
Sulfur	2
Litharge	5
M.B.T.S.	1
Zimate	1
	300.5

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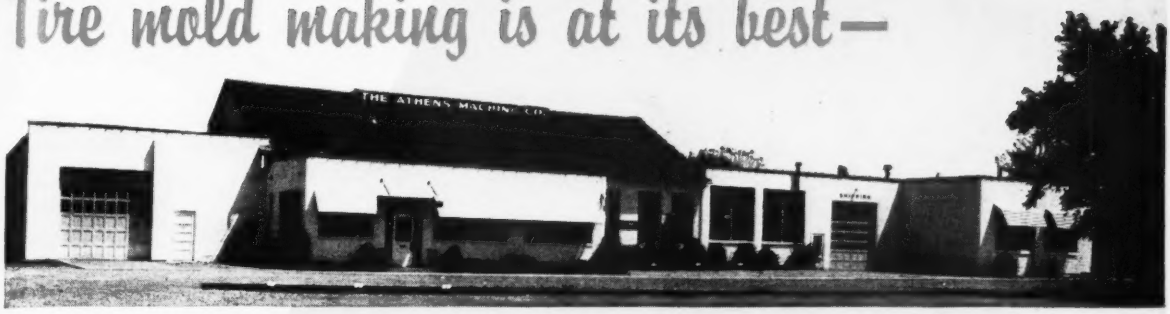
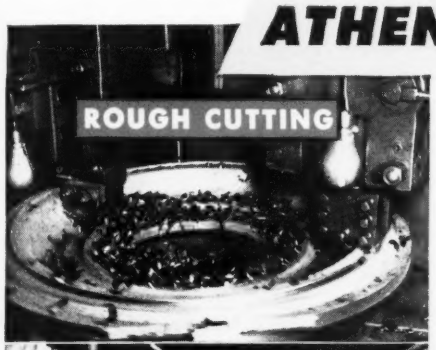
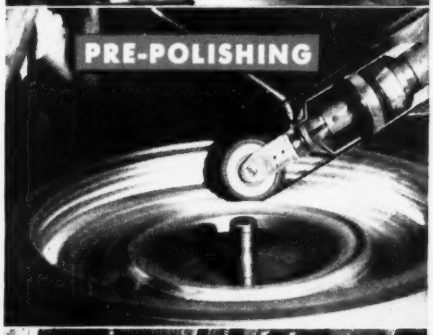
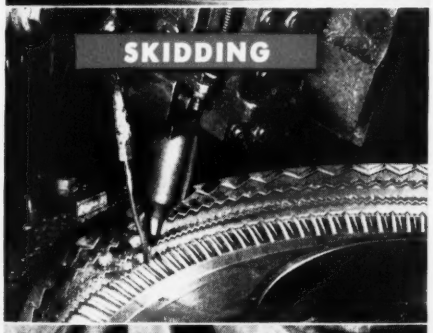


at BRIDGWATER's ATHENS MACHINE DIVISION







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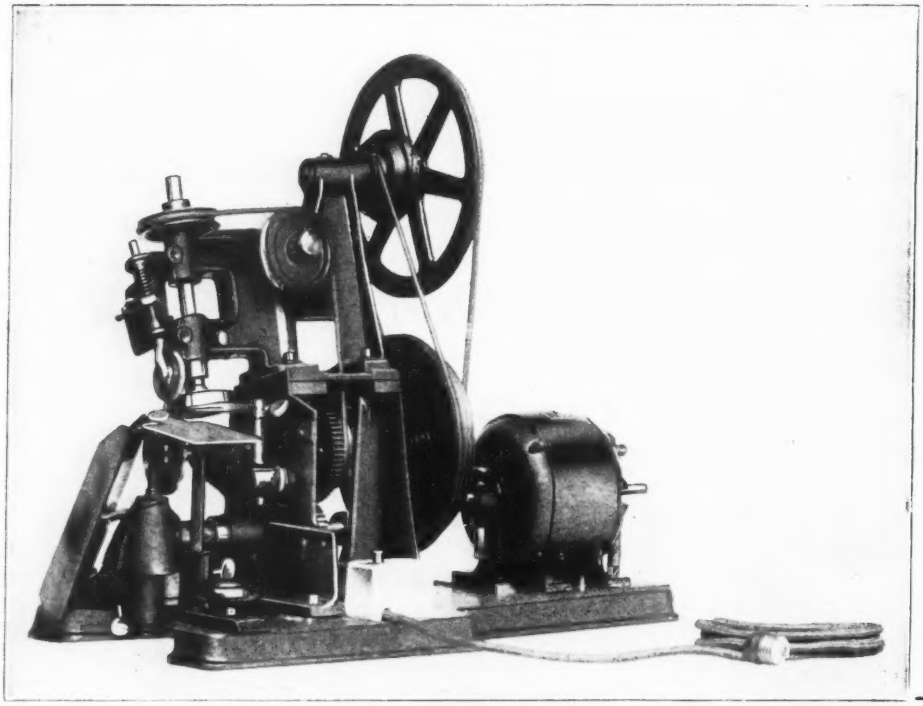

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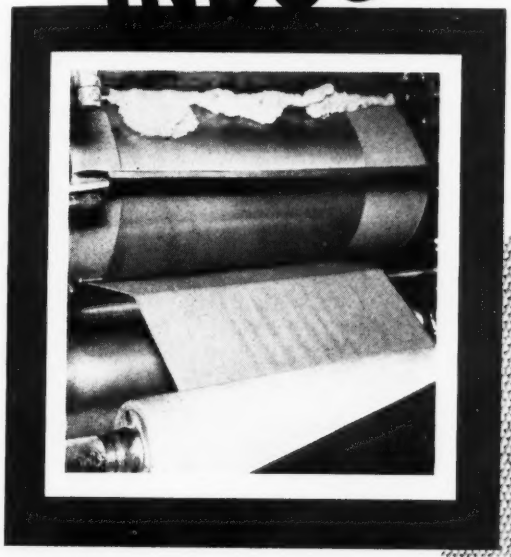

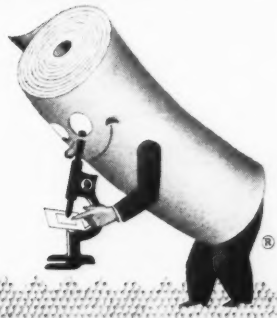

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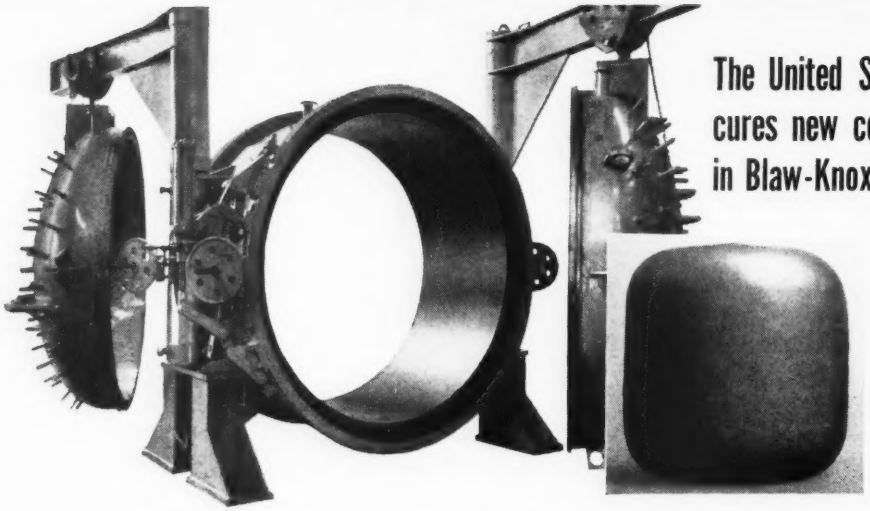

The United States Rubber Company cures new collapsible rubber drums in Blaw-Knox Quick Opening Vessels

U.S. Rubber Company's collapsible, bulk shipping containers are produced in several sizes in Blaw-Knox Pressure Vessels equipped with Quick Opening Doors.

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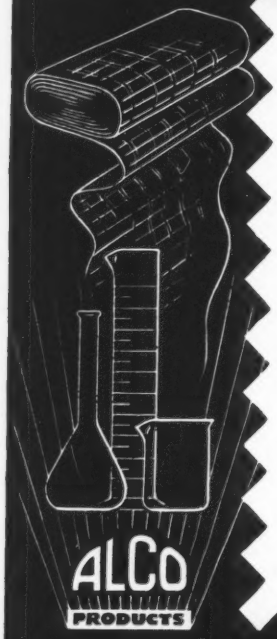
Write for Blaw-Knox Booklet No. 2435.

BLAW-KNOX

BLAW-KNOX COMPANY
Blaw-Knox Equipment Division

Process Equipment Department
Pittsburgh 38, Pennsylvania



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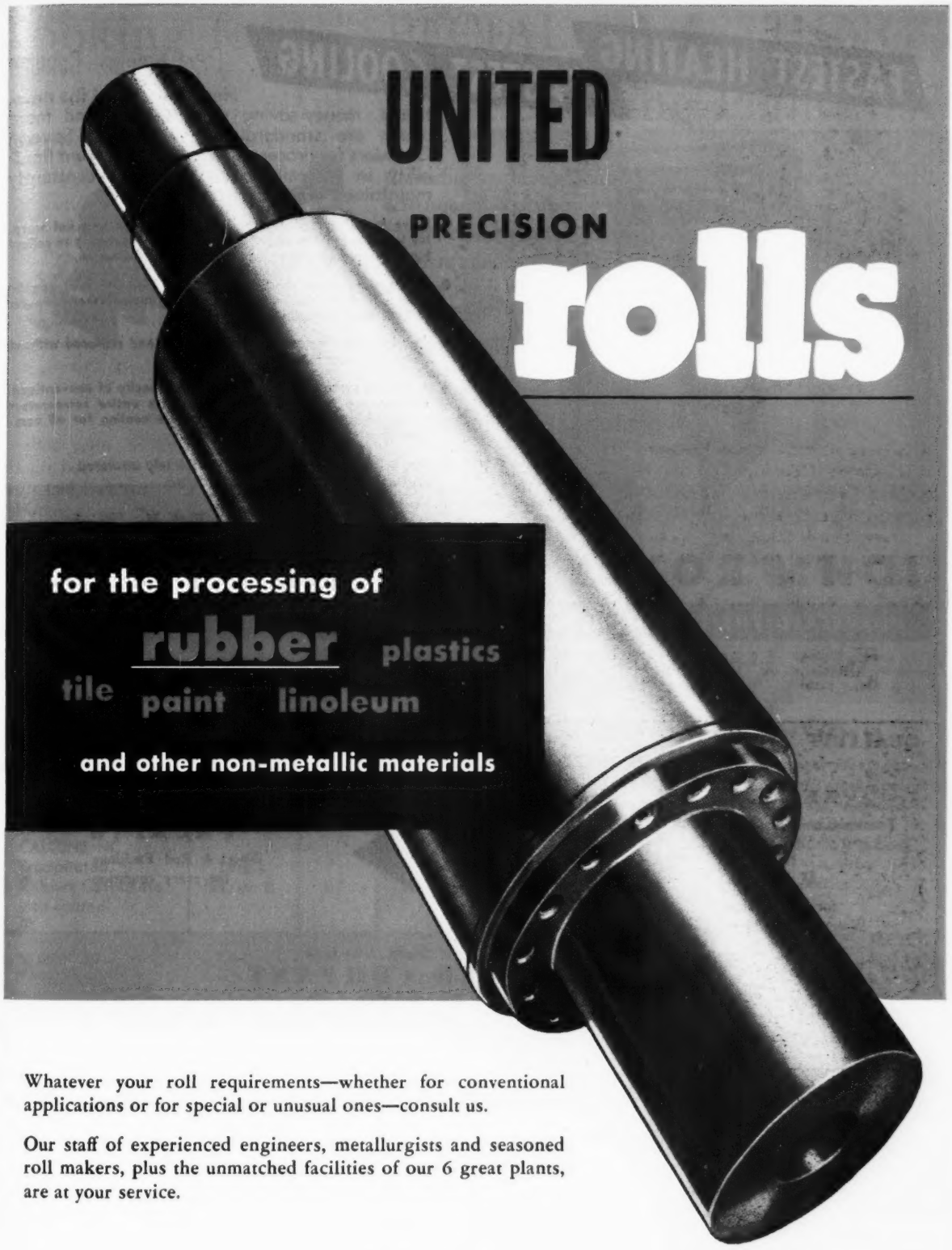

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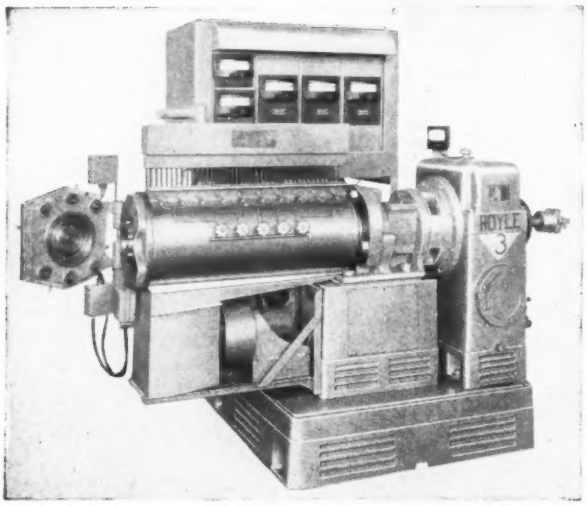

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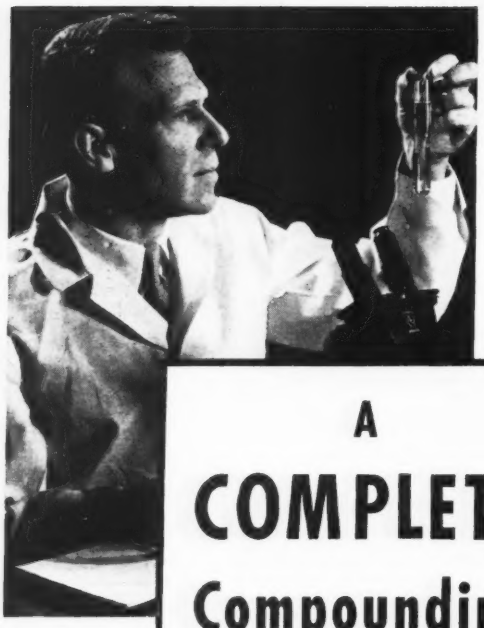

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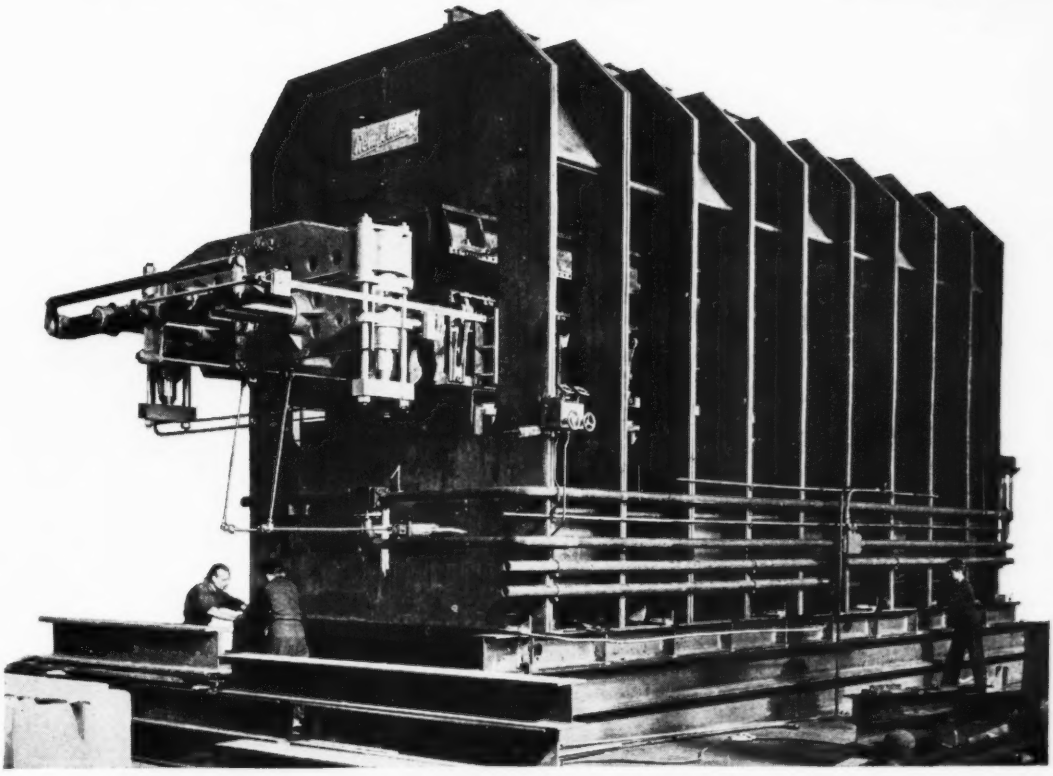
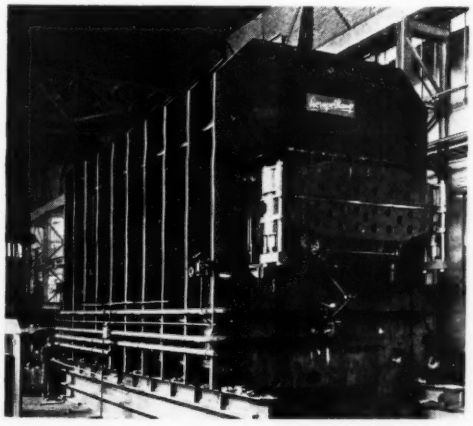
Siempelkamp HYDRAULIC PRESSES



Conveyor Belt Press just completed by Siempelkamp. Hot Plates 35 feet long, 9 feet wide. Pressure 9000 tons.



Note one piece steel frame, no welded sections. Exclusive feature on plates eliminates "bumping" requirement.

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RUBBER WORLD
Vol. 130—No. 5 August, 1954

Editorials

Suggestions for Implementation of Natural Rubber Producer-Consumer Liaison

IN THIS column last month we quoted certain statements made at the International Rubber Study Group meeting held in Colombo, Ceylon, in May relative to the desire of the natural rubber producers to establish closer liaison with consumers, particularly in the United States. We attach great significance to this move and would like to suggest some means of implementing this liaison both from the producer and from the consumer sides.

At this May meeting the International Rubber Study Group Development Committee recommended: "That the International Rubber Research Board and the International Rubber Development Committee arrange discussions with representatives of major consuming countries to consider: (a) whether programs of consumption research and development should be modified to fit in more closely with manufacturers' requirements in consuming countries, and (b) improvement in liaison, where necessary, with manufacturers on matters concerning research and development."

In the United States there are already two committees actively engaged in trying to improve the quality of natural rubber consumed in this country by cooperative efforts with the natural rubber producers and/or dealers. The Crude Rubber Committee of The Rubber Manufacturers Association is concerned primarily with visual market grading specifications and packaging. The crude rubber subcommittee 12 of Committee D-11 on Rubber of the American Society for Testing Materials is concerned with developing specifications and methods of test for natural rubber and has had limited contacts with the International Rubber Research Board in this connection.

It appears that the International Rubber Research Board and the International Rubber Development Committee are established groups on the producing side for effecting liaison, but that neither of the above-mentioned committees in the United States is exactly suited for representing the American consuming industry. The RMA Crude Rubber Committee is not equipped to deal with scientific and technical research and development work although it does have the proper contacts with management in the U. S. rubber industry. The ASTM subcommittee 12, on the other hand, has the necessary scientific and technical personnel, but because it is part of a professional technical society, it is not so free to speak for the U. S. rubber industry as the RMA committee would be.

In a recent letter to the chairman of ASTM subcommittee 12, Norman Bekkedahl, the chairman of the RMA Crude Rubber Committee, W. J. Sears, said that staff members of natural rubber research institutes in the Far East had asked him, "What do the USA manufacturers want in natural rubber?" Mr. Sears has suggested to Dr. Bekkedahl that ASTM subcommittee 12 was particularly well qualified to consider this question, to discuss the implications of the suggestions of international liaison mentioned in the Study Group Development Committee's Report, and to make some tentative recommendations as to how the technicians in the American rubber industry could stimulate greater liaison with producer research organizations.

ASTM D-11 subcommittee 12 could and should consider these matters and as soon as possible. Unfortunately, the next regular meeting of this subcommittee is scheduled for January, 1955. If the ASTM agrees that it is within the scope of D-11 subcommittee 12 to make recommendations along the lines suggested by Mr. Sears, a meeting for this purpose should be held in the early fall. Invitations to this meeting should be extended to members of the RMA Crude Rubber Committee and a few other representative consumers' qualified technical and/or management personnel.

It seems likely that since neither the RMA Crude Rubber Committee nor the ASTM D-11 subcommittee 12 is exactly suited for continued long-term liaison with the International Rubber Research Board and Committee, one of the first items on the agenda should be to consider setting up a new RMA committee, with adequate representation from ASTM D-11 subcommittee 12, Rubber Division, A. C. S., and others, for the purpose of working with the natural rubber producers' committee. It might be that through such liaison more benefits will result both to the producers and the consumers of natural rubber than from any previous effort.

R. G. Seaman

Antiozidants for GR-S Rubber[1]

R. F. Shaw,[2] Z. T. Ossefort,[2] and W. J. Touhey[2]

Stressed GR-S vulcanizates have been protected against atmospheric and accelerated ozone cracking for periods up to two years by incorporation of chemical inhibitors of the alkyl p-phenylenediamine type.

The requirements for an ideal antiozidant, as well as the properties of commercial inhibitors, specially synthesized chemicals, and migratory aids, are presented in some detail.

The investigation reported in this paper was made to determine the factors affecting ozone resistance, such as: polymer type, ozone concentration, stress, type and amount of inhibitor, type and amount of migratory aid, static and dynamic exposure, and oven aging prior to ozone exposure.

ATMOSPHERIC ozone has been shown by many investigators[3] to be the main factor in the deterioration of stressed rubber items such as tires, weatherstrips, wire and hose, exposed to the weather. The cracking of stressed rubber is not always a serious problem even though it is unsightly and appears to be indicative of poor quality in the eyes of the consumer.

In many cases, however, ozone cracks are the focal points for failure caused by flex fatigue. This point is especially true for truck tires which have been in long-term storage or which receive intermittent operation. These cracks progress down to and along the plies and weaken the structure sufficiently, by allowing moisture and air to deteriorate the fabric, to cause premature blowout within several hundred miles after the tire has been placed in service. An example of such a tire is shown in Figure 1.

Ozone Cracking and Its Prevention

The problem of rubber cracking caused by atmospheric ozone has become more pronounced with extensive use of GR-S polymer, including LTP and oil-extended GR-S, by the rubber industry. Although natural rubber is just as susceptible to initiation of cracks by ozone, the stressed surface develops numerous fine cracks which relieve the stress, and the cracks do not progress. In contrast to this condition, stressed GR-S compounds develop fewer cracks, but these cracks progress so as to relieve the stress at isolated points and result in larger cracks which are of a more serious nature in the life of the rubber item. It is estimated that many thousands of dollars worth of military equipment is lost annually because of ozone deterioration.

Present commercial compounding practice for imparting ozone resistance to rubber items is limited to use of inherently resistant specialty polymers; or to compounds or designs which minimize stress effects; or to the use of waxes in the composition which bloom to the surface and provide a protective film which excludes ozone from contact with the rubber surface. This last, of course, does not provide dynamic protection since the wax film is subject to rupture This fault permits cracking to occur with stress relief all at one point, resulting in large cracks.

Protective coatings applied to the surface of non-ozone resistant materials offer protection as long as the film remains unbroken, but then concentrated ozone attack at the point of rupture results in a deep ozone crack. In addition, coatings require prior surface preparation, are costly to apply, and must be reapplied frequently.

The most desirable and feasible method of making general-purpose, ozone resistant GR-S products is to incorporate within the rubber compound at the time of manufacture, several parts by weight of an inhibitor which is specifically an antiozidant. Conventional antioxidants, as used by the industry, impart oxygen resistance, heat resistance, and flex cracking resistance, but there is a great need of an inhibitor which will specifically resist or deactivate atmospheric ozone.

The following characteristics are desirable for such an antiozidant:

1. Specific anti-ozone activity.
2. Non-toxic under conventional processing conditions.
3. Low vapor pressure so as to be retained in the rubber during processing and later service.
4. Resistant to heat aging up to 212° F.
5. Limited solubility in the polymer to provide gradual, continual migration to the surface where it can be effective, since ozone attacks rubber only at the surface.

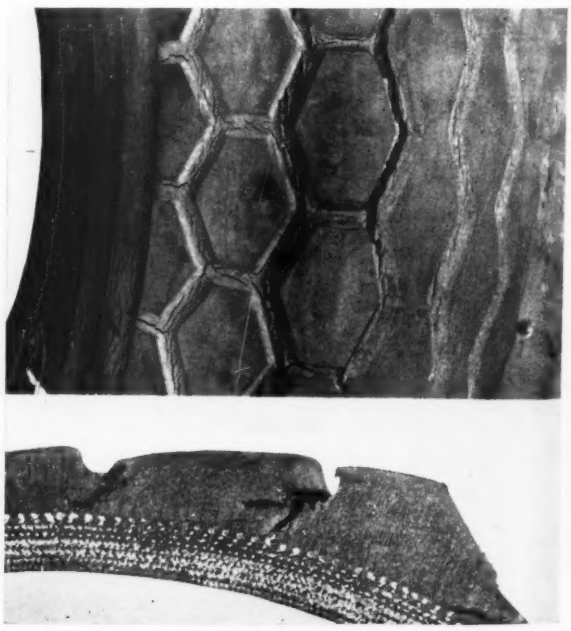


Fig. 1. Truck Tire Tread Cracking Initiated by Ozone (*at Top*); Lower Section Shows Cracks Which Have Penetrated to Carcass Plies

[1]The opinions or assertions contained herein are not to be construed as official or reflecting the views of the Department of the Army.
[2]U. S. Army, Ordnance Corp, Rock Island Arsenal, Rock Island, Ill.
[3]Buist and Welding, *Trans. Inst. Rubber Ind.*, 21, 49 (1945).
Crabtree and Kemp, *Ind. Eng. Chem.*, 38, 278 (1946).
Winkelmann, *Ibid.*, 44, 841 (1952).

6. In the cost range of 50¢ to a dollar a pound.
7. Available in quantity.
8. Non-staining and non-discoloring.
9. Should provide protection to GR-S, natural, and nitrile polymers.

Experimental Procedure

In order to determine if suitable antiozidants existed, numerous commercial antioxidants were incorporated into GR-S compositions and evaluated for ozone resistance. It was determined that GR-S polymers made at low reaction temperatures and with low styrene content were most susceptible to ozone cracking. Therefore GR-S X-600 (GR-S 1505), which is a 90/10 ratio butadiene/styrene copolymer made at 41° F., was selected for this study. Compound formulation is shown in Table 1. Some evaluation was also performed on the same formulation differing only in that an 80/20 polymer made at 41° F. was used These compositions were compounded, milled, and cured in accordance with procedures given in ASTM D15-52T.[4]

TABLE 1. COMPOUND FORMULATIONS

	S12 Series	S47A Series
GR-S 1505 (90/10 @ 41° F.)	100	—
100 (80/20 @ 41° F.)	—	100
Philblack A*	50	50
Zinc oxide	3	3
Stearic acid	2	2
Santocure†	1	1
Sulfur	1.75	1.75
Neozone D‡	1	1
AgeRite Resin D§	1	1
Antiozidant	As indicated	As indicated
Heliozone‡	As indicated	As indicated

All 6- by 6- by 0.080-inch pads cured 30 minutes at 307° F.

*Phillips Chemical Co., Akron, O.
†Monsanto Chemical Co., Akron, O.
‡E. I. du Pont de Nemours & Co., Wilmington, Del.
§R. T. Vanderbilt Co., New York, N. Y.

Test specimens six- by one- by 0.075-inch were cut and mounted in aluminum fixtures in accordance with ASTM D518-44,[4] Method A (at 20% elongation) and Method B (bent loop). The specimens were allowed to rest for 24 hours in the stressed condition prior to exposure to ozone. Figure 2 shows these specimens on an outdoor exposure rack.

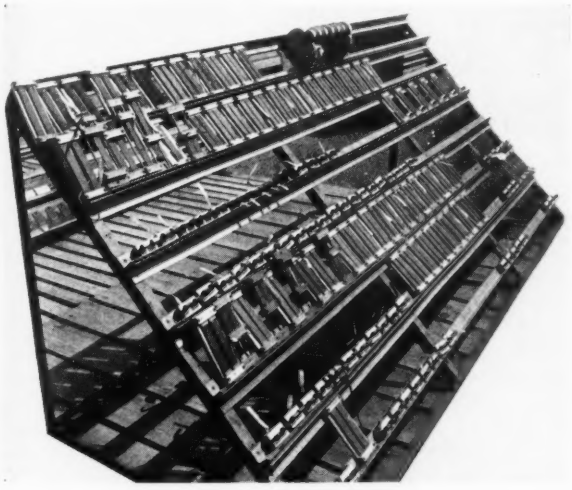


Fig. 2. Outdoor Exposure Rack for Testing Ozone Resistance; Rack at 45-Degree Angle Facing South

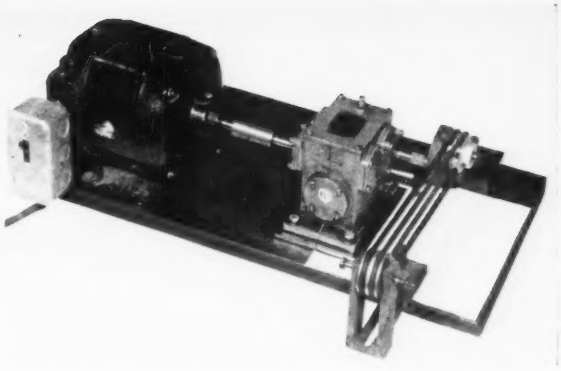


Fig. 3. Rock Island Arsenal Apparatus for Testing Ozone Resistance during Flexing

Dynamic tests were conducted on compounds containing some of these inhibitors in an apparatus of Rock Island Arsenal design mounted outdoors, which alternately stretched to 25% and relaxed to zero stress an O-ring specimen at the rate of four cycles a minute. This apparatus is shown in Figure 3.

Accelerated static exposure tests were conducted within an ozone cabinet constructed in accordance with ASTM D1149-51T[4] and held at 100° F. and 25 ±5 parts ozone per hundred million parts of air. This apparatus is shown in Figure 4.

Additional outdoor static tests were conducted on triangular strips bent around a mandrel, as described in ASTM D1171-51T.[4]

Since the measure of the number, length, or depth of cracks is subject to interpretation, and since quite lengthy periods of no cracking were evident in this study, all ratings were based on the time for appearance of first cracks at 20 magnifications for those specimens exposed in the ozone cabinet or at five magnifications for those specimens exposed outdoors.

The measurement of outdoor ozone concentration was made by using the apparatus and technique described by Bowen and Regener.[5]

Secondary aromatic amines which were higher molecular weight homologs of some promising commercial antioxidants were synthesized, using the pressure hydrogenation technique described in U. S. patent No. 2,323,948. This work was performed by the Augustana Research Foundation under an Army Ordnance contract to conduct basic research on the ozone-elastomer reaction.

Certain commercial waxes consisting of blends of paraffin and microcrystalline waxes with melting points of 70 ±5° C. were investigated at concentrations of one part to three parts per hundred rubber. These concentrations were insufficient to provide significant ozone protection by the waxes themselves, but were beneficial in that the wax served as a carrier or aid for the antiozidant to migrate to the rubber surface.

Several commercial antioxidants were used in conjunction with the wax and antiozidants to enhance the ozone resistance of the rubber composition. The composition of these compounds is shown in Table 2 (which appears on the next page).

The measure of elongation at a given load, as an indication of oven aging resistance, was reported previously.[6]

The dynamic tests at 50 pphm. ozone were conducted in the Firestone weathering apparatus.[7]

[4]"ASTM Standards on Rubber Products, Dec. 1952." American Society for Testing Materials, 1916 Race St., Philadelphia, Pa.
[5]*J. Geophysical Research*, 56, 307 (1951).
[6]Shaw and Adams, *Anal. Chem.*, 23, 1649 (1951).
[7]Ford and Cooper, India RUBBER WORLD, 124, 696 (1951); 125, 55 (1951).

TABLE 2. FORMULATIONS FOR SYNERGESTIC STUDY (EFFECT OF ANTIOXIDANTS AND ANTIOZIDANTS IN COMBINATION)

	S12	S12B	S12 A15B	S12 A16B	S12 A17B	S12 A18	S12 A19	S12 A20
GR-S 1505	100	100	100	100	100	100	100	100
Philblack A	50	50	50	50	50	50	50	50
Zinc oxide	3	3	3	3	3	3	3	3
Stearic acid	2	2	2	2	2	2	2	2
Santocure	1	1	1	1	1	1	1	1
Sulfur	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Neozone D	1	1	—	1	—	—	1	—
AgeRite Resin D	1	1	1	—	—	—	—	1
N, N'-di-sec-butyl-p-phenylene diamine	—	2	2	2	2	—	—	—

Cure: 30 minutes @ 307° F.

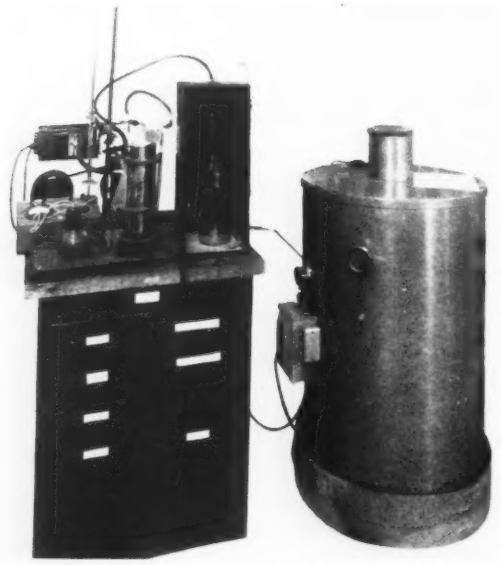
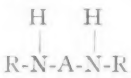


Fig. 4. Crabtree-Kemp Ozone Aging Cabinet for Accelerated Static Exposure Tests

Test Results

The basic structure of the aromatic amines found to be antiozidants is as follows:



where R is hydrogen, phenyl, or alkyl up to 20 carbon atoms, and A is one, two, or three aromatic rings either joined together or separated by small groups such as CH_2. The relation of vapor pressure to molecular weight and to temperature (boiling point) for some of these amines is shown in Table 3.

Aromatic Amines Plus Wax Effective

The time to first crack in ozone for GR-S compounds containing various antiozidants with and without wax as a migratory aid is shown in Table 4. It can be seen that when the molecular weight of the basic structure is increased, the vapor pressure is lowered, and the inhibitor can be considered as more permanent in the rubber. Unfortunately, this larger molecule is also more restricted in its migration through the rubber to the surface where it can be effective in preventing ozone attack. To overcome this slower migration rate, one part of a wax was added to the composition. This small amount of wax, insufficient in itself to provide any measurable ozone resistance, was of considerable value in obtaining maximum migration of the antiozidant.

The solubility of the antiozidant in the rubber compound and the migration through the compound are prime factors in the relative effectiveness of the antiozidant. This migration rate determines the maximum ozone

Fig. 5. GR-S Samples after Exposure Outdoors for 15 Months: *(Left)*—Uninhibited; *(Right)*—5.4 Parts N, N'-Di-Sec-Butyl Benzidine

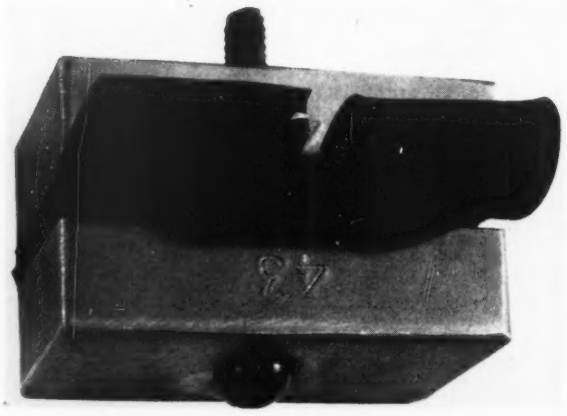


Table 3. PHYSICAL PROPERTIES OF ANTIOZIDANTS

Chemical Name	Calculated Vapor Pressure Mm. Hg @ 100° C.	Molecular Weight	Experimental Boiling Point
N, N'-di-(1'methyl octadecyl) p-phenylene diamine	1.3×10^{-5}	641.1	297° C. @ 0.5 mm.
N, N'-di-(1'methyl hexadecyl) p-phenylene diamine	2.4×10^{-5}	585.0	300° C. @ 0.8 mm.
N, N'-di-(1'methyl dodecyl) p-phenylene diamine	3.7×10^{-4}	472.8	295° C. @ 2.9 mm.
N, N'-di-sec-butyl p-terphenylene diamine	2.0×10^{-4}	372.5	298° C. @ 8.5 mm.
N, N'-di-(1'-methyl decyl) p-phenylene diamine	4.1×10^{-4}	416.7	259° C. @ 3.5 mm.
N, N'-di-(1'methyl octyl) p-phenylene diamine	1.5×10^{-3}	360.6	237° C. @ 3.0 mm.
p, p'-methylene dianiline	3.4×10^{-3}	198.2	222° C. @ 3.0 mm.
N, N'-di-octyl-p-phenylene diamine	5.4×10^{-3}	332.0	237° C. @ 7.0 mm.
N, N'-di-sec-butyl benzidine	1.2×10^{-2}	296.4	208° C. @ 4.0 mm.
N, N'-di-nonyl-p-phenylene diamine	1.5×10^{-2}	360.6	238.8° C. @ 14.5 mm.
N, N'-di-sec-butyl 1, 2, 3, 4, tetrahydro 5, 8 naphthalene dianmie	3.6×10^{-2}	274.4	189° C. @ 4.0 mm.
N, N' bis (p-sec-butyl aminophenyl) 2-3 butane diamine	4.2×10^{-2}	382.5	194° C. @ 5.5 mm.
N, N'-di-sec-butyl (2 methoxy)-p-phenylene diamine	1.4×10^{-1}	250.3	162° C. @ 3.5 mm.
1 (p-sec-butyl aminophenyl) 2, 5 dimethyl pyrrolidine	2.5×10^{-1}	246.4	154° C. @ 4.0 mm.
N, N'-di-sec-butyl p-phenylene diamine	3.9×10^{-1}	220.3	139° C. @ 3.0 mm.
p-Phenylene diamine	2.4	108.1	267° C. @ 760.0 mm.

TABLE 4. TIME TO FIRST CRACK FOR 90/10 BD/STY GR-S COMPOUNDS CONTAINING VARIOUS ANTIOZIDANTS, WITH AND WITHOUT WAX

H—Hour M—Month
D—Day OK—Crack free, test continuing
W—Week BL—ASTM D518-44, Method B, Bent Loop

RIA Cpd. No.	Antiozidant	Amt. 100 RHC	Amt. Wax 100 RHC	ASTM D1149-51T Ozone Cabinet: Original 20% Stress	ASTM D1149-51T Ozone Cabinet: Original BL	ASTM D1149-51T Ozone Cabinet: Aged 7 D @ 158° F. BL	ASTM D1149-51T Ozone Cabinet: Aged 70 H @ 212° F. BL	Outdoors: 20% Stress	Outdoors: BL
S12	None-control	—	—	2H	2H			1D	1D
S12B	N, N'-di-sec-butyl-p-phenylene diamine	2		12M	4M	4H	3H	OK24M	24M
S12B23	N, N'-di-sec-butyl-p-phenylene diamine	4			13M			OK31M	16M
S12B44	N, N'-di-sec-butyl benzidine	2.7		12D	3M			6M	17M
S12B46	N, N'-di-sec-butyl benzidine	5.4		5M				OK25M	23M
S12B68	N, N'-di-sec-butyl benzidine	5.4	1	18M	4M	OK22M	6H	OK21M	OK21M
S12B84	P, P'-diaminodiphenylmethane	2		10D	3D	6H	6H	6M	10M
S12B87	P, P'-diaminodiphenylmethane	4			1M	3D	4H	OK13M	OK13M
S12B85	P, P'-diaminodiphenylmethane	2	1	13M	3D	6H	6H	OK13M	OK13M
S12B88	P, P'-diaminodiphenylmethane	4	1		OK13M	OK13M	6H	OK13M	OK13M
S12B69	N, N'-diphenyl-p-phenylene diamine	2.9	1	3D	3D			13M	11M
S12B57	N, N'-di-sec-butyl 1, 4,-naphthalene diamine	2.5		4H	2H			3D	3D
S12B60	N, N'-di-sec-butyl 1, 4,-naphthalene diamine	4.9		4D	2D			7D	7D
S12B66	N, N'-di-sec-butyl 1, 4,-naphthalene diamine	2.5	1	2M	4D			10M	10M
S12B67	N, N'-di-sec-butyl 1, 4,-naphthalene diamine	4.9	1	7M	2W			14M	OK21M
S12B55	N, N'-bis-(p-sec-butyl aminobiphenyl)-2, 3-butane diamine	2		2H	2H			3D	3D
S12B58	N, N'-bis-(p-sec-butyl aminobiphenyl)-2, 3-butane diamine	4		3H	3H			7D	7D
S12B70	N, N'-bis-(p-sec-butyl aminobiphenyl)-2, 3-butane diamine	2	1	1D	2H			12M	11M
S12B56	N, N'-bis-(p-sec-butyl aminophenyl)-2, 3-butane diamine	2		2H	2H			3D	3D
S12B59	N, N'-bis-(p-sec-butyl aminophenyl)-2, 3-butane diamine	4		2H	2H			7D	7D
S12B71	N, N'-bis-(p-sec-butyl aminophenyl)-2, 3-butane diamine	2	1	1D	2H			9M	10M
S12B86	N, N'-bis-(p-sec-butyl aminophenyl)-2, 3-butane diamine (purified)	2	1		1D	4H	4H	12M	OK13M
S12B51	N, N'-di-sec-butyl-p-terphenylene diamine	3.4		2H	2H			3D	3D
S12B52	N, N'-di-sec-butyl-p-terphenylene diamine	6.8		3D	1D			OK23M	22M
S12B53	N, N'-di-sec-butyl-p-terphenylene diamine	6.8	1	2M	1M			OK23M	OK23M
S12B65	N, N'-di-sec-butyl-p-terphenylene diamine	3.4	1	1D	3H			20M	10M
S12B63	N, N'-di-sec-butyl-2-methoxy-p-phenylene diamine	2		7M	3M			1M	5M
S12B64	N, N'-di-sec-butyl-2-methyl-p-phenylene diamine	2		9M	4M			3M	6M
S12B43	0.50 PBNA 0.25 N, N'-diphenyl-p-phenylene diamine 0.25 di-p-methoxy-diphenyl amine Phenyl-a-naphthylamine	5 5	 5	6H				OK24M	OK24M
S12B47	2, 5-di-4-(sec butyl amino)-phenylamino-hexane	3.7		3M	3M			4M	4M
S12B48	1-sec-butyl amino-4, 1-(2, 5-dimethyl-pyrrolidine)-benzene	2.2		3D	8H			3M	3M
S12B49	1, 1 -di-2, 5-dimethyl-pyrrolidine-1, 4-benzene	2.4		2D	4H			2M	3M
S12B50	1, 1'-di-2, 5-dimethyl-pyrrole-1, 4-benzine	2.4		2H	2H			1D	1D
S12B74	N, N'-di-sec-butyl-1, 2, 3, 4-tetra-hydro-5, 8-naphthalene diamine	2.5	1	7H	5H			16M	7M
S12B77	P-phenylene diamine	2	1	4M	6D			8M	6M
S12B80	Benzidine	2	1	OK14M	OK14M	2M	23H	OK15M	OK15M
S12B91	N, N'-diphenyl benzidine	2	1					3W	3W
S12B81	6-ethoxy-1, 2-dihydro-2, 2, 4-trimethylquinoline	2	1	3D	7H		6H	OK14M	13M
S12B82	0.85 1, 2-dihydro-2, 2, 4-trimethyl-6-phenylquinoline 0.15 N, N'-diphenyl-p-phenylene diamine	2	1	3D	2H		2H	11M	5M
S12B83	0.65 1, 2-dihydro-2, 2, 4-trimethyl-6-phenylquinoline 0.35 N, N'-diphenyl-p-phenylene diamine	2	1	3D	2H			12M	8M
S12B61	Heliozone Wax		1	2H	2H			3W	3W

concentration which can be resisted. It is evident that accelerated testing at 25 or 50 pphm. ozone requires resistance at a *continuous* high ozone concentration; while outdoor testing requires resistance to *intermittent* ozone concentrations ranging from zero to 50 pphm., but usually in the range 3-5 pphm. During these periods of lower ozone concentration, the inhibitor has the opportunity to migrate to the surface and replenish the supply. This inhibitor migration may be one of the reasons which explain the lack of correlation between accelerated tests and atmospheric exposures. Figure 5 shows a GR-S composition both with and without antiozidant after 15 months' outdoor exposure.

Up to three months' protection when the lower molecular weight amines were used without wax was provided in outdoors dynamic tests. With higher molecular weight inhibitors, wax was required for migration, but the small checks which developed did not grow appreciably larger with increase in cycling time.

Polymer Composition, Heat, Aging, Etc.

Amine antioxidants are all considered as being of the staining or discoloring type, and the antiozidants described in this report are no exception to the rule.

Within the GR-S family, the low styrene copolymers

TABLE 5. TIME TO FIRST CRACK FOR 80/20 BD/STY GR-S COMPOUNDS CONTAINING VARIOUS ANTIOZIDANTS, WITH AND WITHOUT WAX

H—Hour M—Month
D—Day OK—Crack free, test continuing
W—Week BL—ASTM D518-44, Method B, Bent Loop

RIA Cpd. No.	Antiozidant	Carrier Amt. 100 RHC	Carrier Amt. Wax	Carrier 100 RHC Other	ASTM D1149-51T Ozone Cabinet Original BL	Aged 7 D @158° F. BL	Aged 70 H @212° F. BL	Outdoors 20% Stress	Outdoors BL
S47AB4	P, P'-diaminodiphenylmethane	4	1		3H	2H	2H	7D	7D
S47A2B6	P, P'-diaminodiphenylmethane	4	3		4D	7D	24D	7M	OK9M
S47EB4	P, P'-diaminodiphenylmethane plus DC 710 Silicone Oil*	4		1	3H	2H	5H	OK9M	5M
S47E1B4	P, P'-diaminodiphenylmethane plus DC 710 Silicone Oil	4		3	22H	5H	5H	7M	5M
S47E2B4	P, P'-diaminodiphenylmethane plus Acrawax C† (powdered)	4		3	4H	2H	8H	OK8M	7M
S47E3B4	P, P'-diaminodiphenylmethane plus castor oil	4		3	4H	2H	2H	OK8M	7D
S47E4B4	P, P'-diaminodiphenylmethane plus glycerol (mono) ricinoleate	4		3	2H	5H	5H	OK8M	1D
S47A2B7	N, N'-di-nonyl-p-phenylenediamine	3	3		OK8M	OK8M	8H	7M	OK8M
S47A3B7	N, N'-di-nonyl-p-phenylenediamine	3	1		OK7M	OK7M	2H	OK7M	OK7M
S47A2B8	N, N'-di-octyl-p-phenylenediamine	3	3		4M	OK7M	8H	7M	OK8M
S47A3B8	N, N'-di-octyl-p-phenylenediamine	3	1		OK7M	OK7M	1D	OK7M	OK7M
S47A3B27	p-aminophenol	3	1		2H	2H	2H	OK4M	3W
S47A3B28	p-aminodiethylaniline	3	1		5H	2H	2H	OK4M	OK4M
S47A3B29	o-aminophenol	3	1		4H	2H	2H	6W	OK4M
S47A3B30	p-phenylenediamine	3	1		OK4M	2H	2H	OK4M	OK4M
S47A3B31	N, N'-diphenylbenzidine	3	1		2H	2H	2H	OK4M	2W
S47A3B33	0.65 diarylamine-Ketone reaction product 0.35 N, N'-diphenyl-p-phenylene diamine	3	1		6H	4H	2H	1M	1W
S47A3B43	nickel-dibutyl-dithiocarbamate	3	1		2W	1W	1D	OK12W	OK12W
S47A3B46	N, N'-diphenyl-p-phenylene diamine	3	1		1D	2H	4H	OK9W	OK9W
S47A3B47	6 ethoxy-1, 2-dihydro-2, 2, 4-trimethylquinoline	3	1		2H	2H	2H	OK7W	OK7W
S47A3B50	6 ethoxy-1, 2-dihydro-2, 2, 4-trimethylquinoline	5	1		2H	2H	2H	OK6W	OK6W
S47A3B51	N, N'-di-4 (2, 6-dimethylheptyl)-p-phenylene diamine	3	1		OK6W	OK5W	2H	OK6W	OK6W
S47A3B52	N, N'-di-n-octyl-p-phenylene diamine	3	1		2H	2H	2H	OK6W	OK6W
S47A3B53	N, N'-di-(1'-methyloctyl)-p-phenylene diamine	3	1		OK6W	OK5W	6H	OK6W	OK6W
S47A3B54	N, N'-di-(1'-methyldodecyl)-p-phenylene diamine	3	1		3D	3D	2H	OK6W	OK6W
S47A3B55	N, N'-di-(1'-methylhexadecyl)-p-phenylene diamine	3	1		2H	2H	2H	OK6W	2W
S47A3B57	N, N'-di-beta-naphthyl-p-phenylene diamine	3	1		2H	2H	2H	2W	2W
S47A3B58	Mixture of mono- and di-heptyl diphenylamines	3	1		2H	2H	2H	2W	2W
S47A3B59	N, N'-di-4 (2, 6-dimethylheptyl)-o-phenylene diamine	3	1		2H	2H	2H	OK2W	OK2W
S47A3B60	N, N'-di-4-(2, 6-dimethylheptyl)-m-phenylene diamine	3	1		2H	2H	2H	7D	7D
S47A2	Heliozone Wax		3		2H	3H	3H	20D	1M
S47E1	DC 710 Silicone Oil			3	2H	2H	2H	6D	6D

*Dow Corning Corp., Midland, Mich.

†Glyco Products Co., Inc., Brooklyn, N. Y.

which, when unprotected, are the most subject to ozone cracking, are the easiest to inhibit by amines. Higher levels of inhibitor and/or carrier are required with higher styrene copolymers, possibly because of differences in solubility, polarity, or association. The time to first crack for 80/20 Bd/Sty GR-S compounds is shown in Table 5.

The value of these antiozidants as antioxidants during heat aging in retaining physical properties is shown in Table 6; while their effectiveness as antiozidants after oven aging is shown in Table 5.

The retention of physical properties, of 90/10 Bd/Sty polymer after oven aging is shown in Table 7. The N, N'-di-sec-butyl-p-phenylene diamine contributes to oven aging resistance, and it, in combination with AgeRite Resin D, is the most heat resistant.

The synergistic effect of antioxidant combinations is shown in Table 8 for 90/10 Bd/Sty polymer which indicates that the addition of either Neozone D or AgeRite Resin D is beneficial in increasing the N, N'-di-sec-butyl-p-phenylene diamine ozone resistance.

The time to first crack for 80/20 GR-S compounds at 50 pphm. ozone in the Firestone weathering apparatus is shown in Table 9.

The atmospheric ozone concentration at Rock Island, Ill., during January to December, 1953, has varied from zero to 10 parts per hundred million parts of air, depending on weather conditions, principally temperature, wind velocity and direction.

No toxicity data have been obtained, but the significant reduction in volatility obtained in going from a 4-carbon alkyl to a 19-carbon alkyl group on the amine should markedly reduce the hazard encountered in handling these chemicals.

Conventional waxes used above in amounts up to three parts based on the GR-S gave protection for only 36 hours in the ozone cabinet and up to 90 days outdoors. This protection is considerably less than that obtained by using antiozidants.

Discussion

It is the opinion of the authors that it is feasible to protect stressed GR-S rubber from the destructive action of atmospheric ozone by the use of the amine antiozidants reported in this paper.

It is realized that further information such as cost, availability, toxicity, and staining are required before commercial use is a reality. The advances in chemistry and technology of synthetic rubber since 1940 by the rubber industry indicates that soon these small obstacles can be overcome, and the users of rubber items can then expect a significant improvement in ozone resistant rubber compositions.

The adaptation of these antiozidants to other polymers is being studied and will in all probability result in similar protection.

TABLE 6. RETENTION OF PHYSICAL PROPERTIES OF 80/20 BD/STY GR-S COMPOUNDS CONTAINING VARIOUS ANTIOZIDANTS

(See Table 5 for Inhibitor Used)

Test	S47AB4	S47A2B6	S47EB4	S47E1B4	S47E2B4	S47E3B4	S47E4B4	S47A2B7	S47A3B7
Original:									
Tensile, psi	2580	2530	2710	2490	2750	2700	2590	2630	2470
300% Modulus, psi	2160	1020	1410	1270	1400	1170	1100	1010	990
% Elongation	380	650	510	520	540	590	580	640	610
Shore A Hardness	76	65	71	69	70	68	65	65	64
NBS strain*	36	81	60	73	66	76	79	93	87
Aged 7 days @ 158° F.									
Tensile, psi	2810	2330	2850	2670	2540	2690	2650	2690	2650
300% modulus, psi	——	1480	2160	1820	1900	1750	1770	1360	1150
% Elongation	310	470	410	430	400	450	400	530	560
Shore A hardness	82	70	77	72	73	71	70	66	68
NBS strain	28	54	37	47	44	51	49	66	60
% Weight loss	0.6	0.8	0.59	0.65	0.44	0.48	0.54	0.67	0.61
Aged 70 hrs. @ 212° F.									
Tensile, psi	2590	2450	2690	2130	2660	2450	2530	2730	2510
300% modulus, psi	——	2040	——	——	——	——	——	1810	1840
% Elongation	220	360	300	250	280	310	290	450	380
Shore A hardness	86	74	78	78	77	72	72	70	70
NBS strain	18	39	30	34	30	38	35	55	47
% Weight loss	1.0	1.5	1.3	1.4	1.0	0.86	1.9	1.2	1.85

Test	S47A2B8	S47A3B53	S47A3B54	S47A3B55	S47A2	S47E1
Original:						
Tensile, psi	2550	2330	2380	2390	2710	2620
300% Modulus, psi	940	1250	1240	1160	1190	1090
% Elongation	610	550	530	550	560	610
Shore A hardness	63	63	64	63	68	67
NBS strain	92	82	74	75	75	—
Aged 7 days @ 158° F.						
Tensile, psi	2590	2380	2210	2350	2710	—
300% Modulus, psi	1340	1560	1420	1470	1940	—
% Elongation	520	460	470	490	390	—
Shore A hardness	67	66	65	65	71	69
NBS strain	67	59	59	59	43	—
% Weight loss	0.61	0.53	0.40	0.40	0.6	0.37
Aged 70 hrs. @ 212° F.						
Tensile, psi	2560	2260	2310	2440	2550	—
300% Modulus, psi	1700	1840	1890	1920	—	—
% Elongation	430	370	400	380	320	—
Shore A hardness	69	69	70	70	74	73
NBS strain	57	48	44	44	35	—
% Weight loss	1.4	1.3	0.98	1.1	1.2	0.9

*National Bureau of Standards strain test: % Elongation under 200 psi. after 60 seconds.

TABLE 7. RETENTION OF PHYSICAL PROPERTIES OF 90/10 BD/STY GR-S COMPOUNDS DURING AIR OVEN AGING

(See Table 2 for Compound Formulation)

	Tensile, psi.			% Elongation			Hardness—Shore A			NBS Strain % E @ 200 Psi.		
Compound	Original	Aged 7 Days @ 158° F.	Aged 70 Hrs. @ 212° F.	Original	Aged 7 Days @ 158° F.	Aged 70 Hrs. @ 212° F.	Original	Aged 7 Days @ 158° F.	Aged 70 Hrs. @ 212° F.	Original	Aged 7 Days @ 158° F.	Aged 70 Hrs. @ 212° F.
S12	2315	2745	1850	500	380	250	62	72	74	90	57	41
S12B	2230	2570	2525	460	480	320	63	70	74	82	53	37
S12A15B	1920	2475	2230	490	430	330	64	69	73	87	64	47
S12A16B	2250	2300	2110	480	440	290	64	69	73	83	56	40
S12A17B	2125	2325	1920	440	370	280	62	67	74	82	57	42
S12A18	2300	2575	2390	490	360	290	63	69	71	77	45	40
S12A19	2440	2435	2445	470	340	290	63	68	71	77	46	42
S12A20	2445	2440	2060	470	340	270	64	70	71	72	44	40

TABLE 8. SYNERGISM STUDY—TIME TO FIRST CRACK

		ASTM D1149-51T Ozone Cabinet					
		Original		Aged 70 Hrs. @ 212° F.	Aged 7 Days @ 158° F.	Outdoors	
Compound Number	Inhibitor	20% Stress	BL	20% Stress	20% Stress	20% Stress	BL
S12	N, A	2H	2H			1D	1D
S12B	T, N, A	12M	4M	3H	4H	OK21M	OK21M
S12A15B	T, A	9M	2M	3H	4H	OK21M	OK21M
S12A16B	T, N	OK21M	2W	2H	4H	8M	6M
S12A17B	T	7M	2W	2H	4H	8M	4M
S12A18	——	2H	2H			1D	1D
S12A19	N	2H	2H			1D	1D
S12A20	A	2H	2H			1D	1D

H—Hours
D—Days
W—Weeks
M—Months
OK—Crackfree, test continuing

BL—ASTM D518-44, Method B Bent Loop
T—N, N'-di-sec-butyl-p-phenylene diamine (phenyl-b-naphthylamine)
N—Neozone D
A—AgeRite Resin D (tri methyl dihydroquinoline)

TABLE 9. TIME TO FIRST CRACK FOR 80/20 GR-S COMPOUNDS CONTAINING VARIOUS ANTIOZIDANTS IN THE FIRESTONE WEATHERING APPARATUS

Ozone concentration: 50 ± 5 pphm.
Temperature: 100 ± 1° F.
Dynamic flex: 0 to 20%
Static stress: 20%

Note: This test was run continuously Monday through Friday.

OK: Indicates specimen crackfree, test continuing.

RIA Cpd. No.	Antiozidant	Amt. 100 RHC	Amt. Wax	Time to First Crack in Hours	
				Static	Dynamic
S47A2B7	N, N'-di-nonyl-p-phenylene diamine	3	3	OK1440	7
S47A3B7	N, N'-di-nonyl-p-phenylene diamine	3	1	OK1440	7
S47A2B8	N, N'-di-octyl-p-phenylene diamine	3	3	OK1440	23
S47A3B8	N, N'-di-octyl-p-phenylene diamine	3	1	OK1440	23

Conclusions

The following conclusions are based on the results obtained in this study:

1. Atmospheric ozone is responsible for the cracking of stressed GR-S rubber during aging.

2. Within the GR-S polymer family, the tendency to crack is increased by low styrene content and low polymerization temperature.

3. Certain amines, principally alkyl p-phenylene diamines are effective antiozidants when three to five parts per hundred are incorporated in GR-S. Stressed samples exposed outdoors remained crackfree over two years.

4. Migratory aids such as wax are required to assist the bulky, higher molecular weight antiozidants to the surface where they can be effective.

5. Conventional general-purpose antioxidants, also of the amine type, such as Neozone D and AgeRite Resin D are effective in enhancing the ozone resistance imparted to GR-S by amine antiozidants.

6 The long crackfree exposure periods of stressed GR-S experienced during this study indicate that the measure of the number, length, width, or depth of ozone cracks is of minor importance since the absence of any cracking is desired and can be obtained.

7. The fluctuation of atmospheric ozone concentrations makes outdoor exposure tests difficult to correlate with accelerated ozone cabinet tests since the reaction rate of ozone with the inhibitor is governed by the ozone concentration and the migration rate of the antiozidant to the rubber surface.

8. The solubility of the antiozidant in the polymer and the molecular weight, size, and vapor pressure of the antiozidant are prime factors in the migration and permanence characteristics of the antiozidant.

9. Amine antiozidants function also as antioxidants in GR-S on heat aging, but tend to lose their effectiveness in subsequent ozone exposure.

10. Static ozone resistance is easier to obtain than dynamic ozone resistance.

11. The optimum antiozidant characteristics of the amines studied are represented by those such as N, N'-di-octyl-p-phenylene diamine, which represent a balance between high molecular weight (low vapor pressure and slow migration rate) and low molecular weight (high vapor pressure and fast migration rate).

Acknowledgment

The authors wish to express their appreciation to the Ordnance Corps, United States Army, for permission to publish this paper and to Universal Oil Products Co., Des Plaines, Ill., for supplying samples of the di-octyl and di-nonyl p-phenylene diamine.

Styropor—Badische's Expandable Polystrene

Styropor is the name given to expandable polystyrene produced by a new process at the plastics material laboratory of Badische Aniline & Soda Fabrik, Ludwigshaven, Germany. The material, available both as granules and blocks, resembles the firm's Polystyrene III chemically and in its general properties, but in addition contains a blowing agent so that foamed polystyrene can be made directly without further compounding.

When heated above the softening point of 65-70° C., in hot water or steam, Styropor expands up to 40 times its original bulk, assuming a microporous structure and snow-white color; the increasing volume of the blowing agent at elevated temperatures is responsible for the pore formation. The specific gravity of the material can be varied, as required, by regulating the working temperature and time of treatment.

Granulated Styropor is the preferred form since it permits greater flexibility in processing and application. Block Styropor is supplied in sealed tins in the form of cylinders about four by ten inches, which are sawed into disks about half an inch thick before expansion in hot water. In block form, the material is used primarily for electrical insulation in the form of ribbon cut from circular expanded disks.

All shapes and kinds of articles can be molded from granulated Styropor, and inserts of metal or other materials can be included in the finished product. It can be sawed, drilled, cut, split into thin sheets, or shaped with a band saw; usually it cannot be welded. The expanded plastic is 10-15 times lighter than cork, and its heat conductivity is lower, so that it can replace cork for many uses to advantage. Toys, display models, partitions, paneling, insulating layers under floors, etc., can be made from it.

Styroper seems to be related, if not identical with, the expanded polystyrene beads now being produced in the United States by the Koppers company.[1]

[1] RUBBER WORLD, JUNE, 1954, p. 373.

Changes in Elastomers Due to Radiation from Cobalt-60

S. D. Gehman[1] and L. M. Hobbs[2]

This paper provides background information for applications of elastomers and plastics in which they are exposed to intense radiation.

A variety of elastomers and plastics was exposed to gamma radiation from a 10,000-curie cobalt-60 source for an integrated exposure of 10^8 rep. The samples were sealed in nitrogen to avoid effects of oxygen and ozone.

A wide variation in physical properties was found in the effects of the radiation dose, depending upon the type of elastomer and variations in the compounding agents and conditions. In general, the complex character of the results encouraged explanations of the effects in terms of free radical reactions.

THE effects on plastics and elastomers of large doses of radiation from radioactive sources have been the subject of a number of published investigations. Davidson and Geib[3] reported results of the exposure of elastomers, mostly uncured, to pile radiations. Lawton, Bueche, and Balwit[4] employed an artificially produced beam of 800-kv. electrons. They listed two classes of polymers, those which were cross-linked by the radiation and those which were degraded.

The most thorough study of the effects for any one polymer is presented by the investigations of Charlesby[5-7] on polyethylene. This work also gives an excellent appraisal of the general nature of the reactions and changes which radiation may be expected to induce in hydrocarbon polymers.

Ryan[8] has published the results of exposure of a variety of elastomers to intense gamma radiation. Wall and Magat[9] and Berstein, Farmer, Rothschild, and Spalding[10] studied the effects of radiation on polymerization reactions, with results which are illuminating in a general way in regard to the reactions of radiation on polymers themselves.

There is still required a great deal of background information on radiation induced changes in elastomers to understand these changes scientifically and to use the elastomers most advantageously. The present work is a survey of the effects of a large dose of gamma radiation on a variety of elastomers and compounds. It adds to work already published, by the greater variety of elastomers and elastomer compounds studied, by giving the formulae of many of the compounds used, by the more exact specification of the type of radiation and the temperature during the exposure, and by the exclusion of possible effects due to the presence of oxygen.

Experimental Procedure

The radiation source was a vertical array of cobalt-60 rods at the University of Michigan rated at 10,000 curies[11] of activity.[12] Cobalt-60 is a gamma emitter. It gives off electromagnetic radiations similar to X-rays, but of shorter wave length. The gamma radiation of cobalt-60 would correspond to X-rays with excitation voltages of 1.1 and 1.3 million volts. Materials exposted to Co-60 radiation do not become radioactive as is usually the case with pile irradiation.

The elastomer or plastic compounds were mounted in a position near the rods where the intensity was about 100,000 rep. per hour. The rep., "Roentgen equivalent physical," is that amount of ionizing radiation which, on absorption in animal tissue, is accompanied by the gain of 93 ergs per gram of tissue.[13] For Co-60 radiations, the rep. is roughly equivalent to 1.6×10^9 photons/cm.^{2} A photon[14] is a discrete portion of energy, a packet of electromagnetic waves, the value of which is defined, according to quantum theory, as the product of Planck's constant by frequency. The dose used in this work was 10^8 rep., representing a totalized exposure to the source of 500-1,000 hours.

The use of such a source provides a simplification of conditions for this type of work, as compared to exposure to radiations in a pile. In a pile there are complications of an elevated temperature, possible induced radioactivity in the samples, and more heterogeneous radiations.

The presence of ozone in the cave was noticeable so that the samples were sealed in a nitrogen atmosphere to eliminate the possibility of ozone attack. In the first run the samples were sealed under nitrogen in a package of polyethylene film. In the second experiment duplicate samples as well as additional elastomers were sealed in a dessicator which had been flushed out with nitrogen. Although the polyethylene sheets employed in the first experiment deteriorated, the results for the similar samples in the two experiments were essentially identical; therefore it was concluded that oxygen effects had been eliminated in both experiments. Hence the results given for many of the compounds represent the average of measurements of the properties of the samples from the two experiments.

The vulcanized elastomers were prepared as test sheets nominally 0.080-inch in thickness. The uncured elastomers were pressed out into sheets about 0.1-inch gage

[1]Goodyear Tire & Rubber Co., Akron, O.
[2]Associate professor of chemical engineering and director of Michigan Memorial-Phoenix Project 43, University of Michigan, Ann Arbor, Mich.
[3]*J. Applied Phys.*, 19, 427 (1948).
[4]*Nature*, 172, 76 (1953).
[5]*Proc. Royal Soc.*, A215, 187 (1952).
[6]*Ibid.*, A217, 122 (1953).
[7]*J. Polymer Sci.*, 10, 201 (1953).
[8]*Nucleonics*, 11, 8, 13 (1953).
[9]*Modern Plastics*, 30, 11, 111, (1953).
[10]*J. Chem. Phys.*, 21, 1303 (1953).
[11]A curie of radioactivity represents the same number of atomic disintegrations per second as occurs for one gram of radium.
[12]*Nucleonics*, 12, 1, 40 (1954).
[13]"Radiological Monitoring Methods and Instruments," National Bureau of Standards Handbook 51, NBS, Washington 25, D. C. (1952).
[14]"X-Rays in Practice," W. T. Sproull, McGraw-Hill, Inc. New York, N. Y. (1946).

TABLE 1. COMPOUND FORMULAE

	A	B	C	D	E	F	G	H	I
GR-I 18 (Butyl)		100							
GR-S 100 (cold rubber)				100	100		100		
Neoprene GN*			100						
Natural rubber (Smoked Sheet)						100		100	
Chemigum N† (55/45 Butadiene acrylonitrile)	100								
Hypalon*									100
Sulfur	1.75	3			2	3	2	2.75	
Zinc oxide	5	5	5	3.5	3.5	5	3.5	5	
Stearic acid	1.5	3	1	1.5	1.5	1.5	1.5	3	
Pine tar								5	
Tricresylphosphate	10								
Phenyl-b-naphthylamine	1								
Staybelite A‡									2.5
Captax§						1			3
Altax§	1.75				1		1.5	0.75	
Tuads§		1		4				2	
Silene FF¶									60
Fumed litharge									20
Magnesia			4						
HAF carbon black						50	50		
SRF carbon black	60								

*E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
†Goodyear Tire & Rubber Co., Akron, Ohio.
‡Hercules Powder Co., Inc., Wilmington, Del.
§R. T. Vanderbilt Co., New York, N. Y.
¶Columbia Southern Chemical Corp., Barberton, O.

at 275° F., placed between heavy aluminum foil, and clamped flat at room temperature for 24 hours. They were exposed in the aluminum foil.

Stress-strain tests were made with an Instron[15] tester; the control test pieces were measured at the same time as the exposed test pieces in order to eliminate normal aging effects. For the vulcanized samples, small dumbbells were used, the neck was 1/10-inch wide and about 3/4-inch long. Crosshead speed was 10 inches a minute, and chart speed 20 inches a minute. The raw polymers were tested in the form of strips, one inch wide. All of the elastomers used were commercial materials. The temperature during irradiation was in range from 60-70° F. The testing temperature was 77° F.

Compound Formulae

The formulae of compounds which were prepared especially for this work are listed in Table 1. Additional compounds used had been formulated for mechanical goods purposes.

Discussion of Results

Results from the stress-strain records are given in Table 2, and some of the stress-strain curves are illustrated in Figures 1-8.

It must be realized that the effects of the radiation are complex and such comparisons may be affected by the dose, the dose rate, and the type of radiation. Charlesby,[5] however, has pointed out that qualitatively the effects from various types of high energy radiation should be very similar. This similarity is due to the fact that only a very small proportion of the molecules are affected directly by the primary radiation. The molecules are activated principally with relatively small energies available from the degradation of the incident high energy radiation by successive interactions with the electrons and nuclei.[16]

Thus the classification of elastomers as those which are cross-linked by irradiation and those which are broken down, arrived at by experiments using 800-kv. electrons,[4] is, in general, evident also in this work with a gamma ray source. Ryan,[8] on the other hand, used gamma rays from the Hanford "cooling off" pit and found stiffening only. The most probable reason for this difference in the results lies in the size of the radiation dose. The gamma flux used by Ryan was 10^{11} photons/cm^2 sec. for a period of six months, about 10 times the dose used in this work.

Charlesby[5] recognized three stages in the effect of the dose on polyethylene. In the first stage there was slight cross-linking, with little change in properties; in the second stage, the cross-linking was extensive, but the properties were still similar to ordinary polyethylene at room temperature; in the third stage the polyethylene became glass-like, discolored, and brittle.

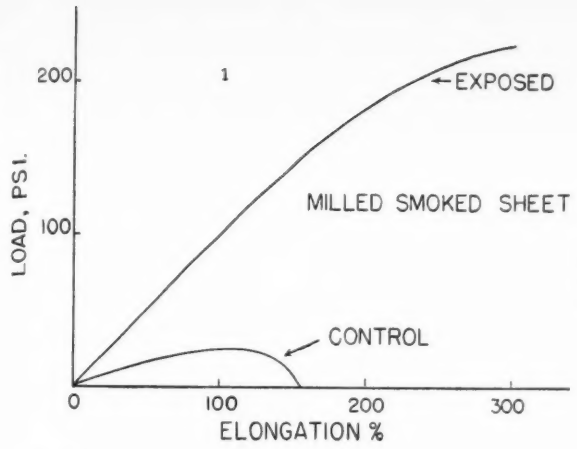
It is quite possible, as is indicated by a comparison of the results, that some of the elastomers such as Chemigum SL and Thiokol should actually show some degradation or softening before the final stage of embrittlement sets in. Both the Butyl gum stock and raw Butyl rubber were reduced to a sticky "goo" by the exposure. This effect is a characteristic of free radical agents on Butyl rubber, as compared to their cross-linking action with most elastomers. Thus the experiments with Butyl rubber are a striking confirmation that the effects of radiation on elastomers are brought about by free radical mechanisms.

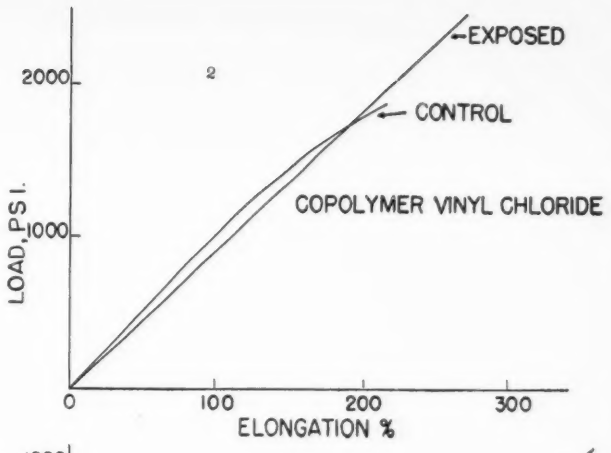
Charlesby[5] recognized the occurrence of surface oxidation of polyethylene during exposure to radiation. No evidence of oxidation could be seen in the infrared absorption spectrum of the irradiated Butyl rubber.

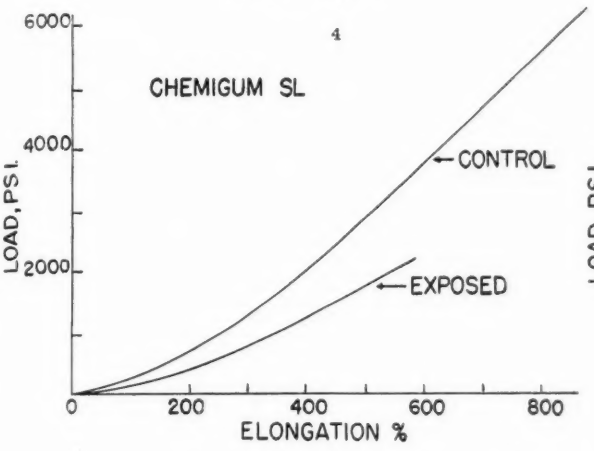
The sample of polyethylene listed in Table 2 was not sealed in nitrogen, as were the other samples, but was taken from the container bag used in the first run. It was commercial film, 0.0015-inch gage. After the exposure, a strong band occurred in the infrared spectrum at about 5.8μ, showing that oxidation did contribute to the change in properties which occurred. The 5.8μ band is characteristic for the carbonyl group in organic compounds.

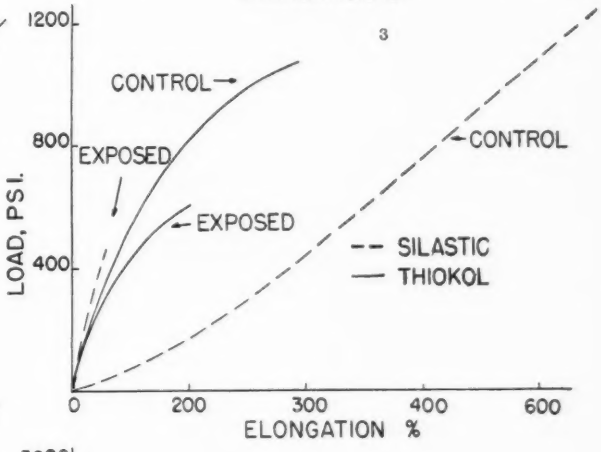
[15]Instron Engineering Corp., Quincy, Mass.
[16]*Nucleonics*, 11, 8, 8 (1953).

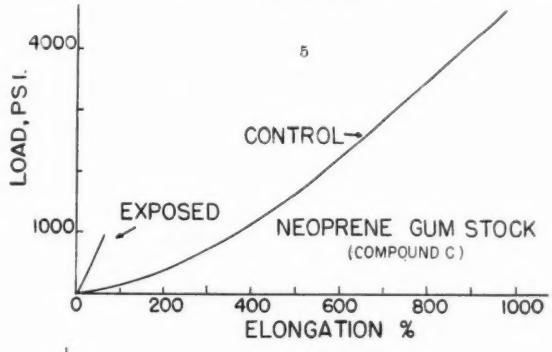
Fig. 1-8. *(See Opposite Page)* Effect of Radiation Exposure on the Stress-Strain Properties of Various Elastomers and Plastics: (1) Milled Smoked Sheet Rubber; (2) Vinyl Chloride Copolymer; (3) Silastic and Thiokol; (4) Chemigum SL; (5) Neoprene Gum Stock; (6) Chemigum N; (7) Tread Stocks of LTP GR-S and of Natural Rubber; (8) LTP GR-S Gum Stocks, Sulfur and Sulfurless Acceleration

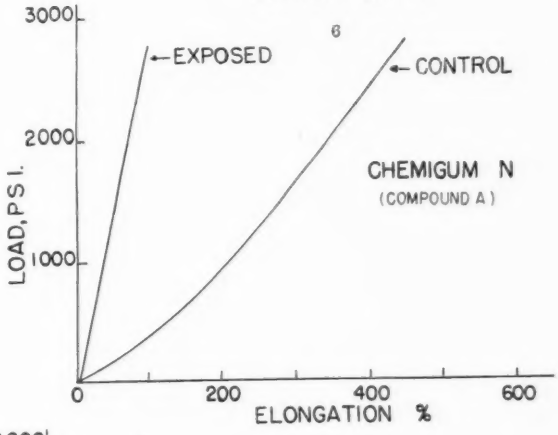

1
200
100
LOAD, PSI.
EXPOSED
MILLED SMOKED SHEET
CONTROL
0
100
200
300
ELONGATION %

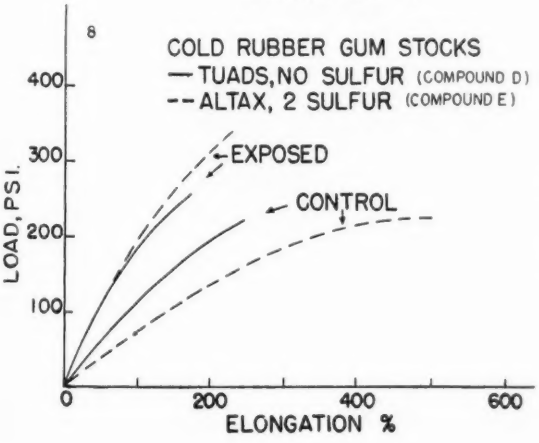

2
2000
1000
LOAD, PSI.
EXPOSED
CONTROL
COPOLYMER VINYL CHLORIDE
0
100
200
300
ELONGATION %


4
6000
4000
2000
LOAD, PSI.
CHEMIGUM SL
CONTROL
EXPOSED
0
200
400
600
800
ELONGATION %


3
1200
800
400
LOAD, PSI.
CONTROL
EXPOSED
CONTROL
EXPOSED
-- SILASTIC
— THIOKOL
0
200
300
400
600
ELONGATION %


5
4000
1000
LOAD, PSI.
CONTROL
EXPOSED
NEOPRENE GUM STOCK
(COMPOUND C)
0
200
400
600
800
1000
ELONGATION %


6
3000
2000
1000
LOAD, PSI.
EXPOSED
CONTROL
CHEMIGUM N
(COMPOUND A)
0
200
400
600
ELONGATION %


8
COLD RUBBER GUM STOCKS
— TUADS, NO SULFUR (COMPOUND D)
-- ALTAX, 2 SULFUR (COMPOUND E)
400
300
200
100
LOAD, PSI.
EXPOSED
CONTROL
0
200
400
600
ELONGATION %

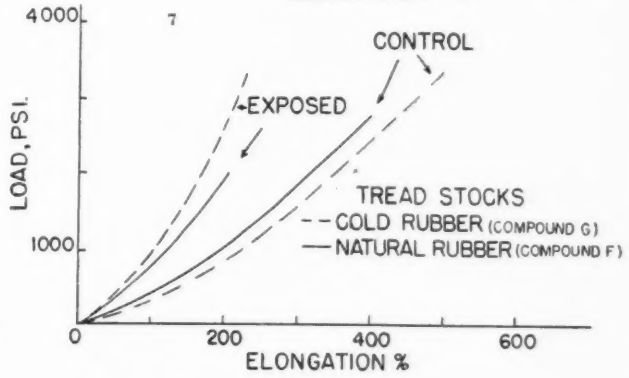

7
4000
1000
LOAD, PSI.
CONTROL
EXPOSED
TREAD STOCKS
-- COLD RUBBER (COMPOUND G)
— NATURAL RUBBER (COMPOUND F)
0
200
400
600
ELONGATION %

TABLE 2. EFFECT OF COBALT-60 RADIATION ON STRESS-STRAIN PROPERTIES EXPOSURE: 10^5 REP; GAMMA RAYS, 1.1; 1.3 MEV.

Compound	Material	Cure Min./° F.	100% Modulus, Psi. Orig-nal	Ex-posed	% Change	Tensile Strength, Psi. Orig-nal	Ex-posed	% Change	Ultimate Elongation, % Orig-nal	Ex-posed	% Change
Mech. Gds.	Natural rubber	30/275	107	197	+84	3400	2600	−24	715	645	−10
Mech. Gds.	Natural rubber	30/275	387	652	+68	4000	2835	−29	562	367	−35
F	Natural rubber	20/290	372	748	+101	2800	2040	−27	403	210	−47
H	Natural rubber	10/311	67	135	+101	1750	2080	+19	660	590	−11
H	Natural rubber	20/311	67	130	+94	1650	1820	+10	700	570	−19
H	Natural rubber	30/311	95	131	+38	1700	1500	−12	740	540	−27
	Milled Smoked Sheet	———	24	98	+308	25	225	+800	157	303	+93
Mech. Gds.	Cold rubber	30/275	297	595	+100	3035	2525	−17	520	310	−40
G	Cold rubber	40/290	321	982	+206	3365	3300	−2	505	230	−54
D	Cold rubber	30/290	116	194	+67	264	265	0	313	160	−49
D	Cold rubber	60/290	113	190	+68	226	258	+14	245	168	−31
E	Cold rubber	30/290	48	150	+212	361	238	−34	1000	212	−79
E	Cold rubber	60/290	77	192	+151	225	338	+50	499	230	−54
	Cold rubber	———	22			16	80	+400	918	52	−94
A	Chemigum N	45/290	390	2790	+615	2820	2790	−2	445	100	−78
A	Chemigum N	90/290	398			2820	2880	+2	440	80	−82
Mech. Gds.	Chemigum N	30/290	256	1170	+356	1670	1410	−16	562	122	−78
Mech. Gds.	Chemigum N	35/295	580			1980	1750	−12	300	85	−72
Mech. Gds.	Chemigum N / GR-S	30/295	370	2160	+480	2260	2240	−1	425	105	−75
Mech Gds.	Chemigum N / Vinylite*	40/305	500	22		2240	2320	+36	465	60	−87
Mech. Gds.	Vinyl chloride copolymer	5/295	1000	910	−9	1870	2460	+32	215	272	+27
C	Neoprene	30/290	140			4115	400	−90	983	67	−93
C	Neoprene	50/290	153			4695	372	−92	980	68	−93
Mech. Gds.	Neoprene	30/295	124			2285	1358	−41	885	88	−90
Mech. Gds.	Neoprene-GR-S	30/295	540			2410	1600	−34	325	55	−83
Mech. Gds.	Thiokol†	30/295	540	435	−20	1080	610	−44	293	177	−40
Mech. Gds.	Silastic‡	10/260	71			1300	450	−65	725	55	−92
	Chemigum SL	15/280	298	150	−50	6350	2260	−65	880	590	−33
I	Hypalon	25/290	455			1655	1430	−14	164	19	−88
	Polyethylene		2200			2300	1080	−53	115	6	−95

*Bakelite Corp., New York.
†Thiokol Corp., Trenton, N. J.
‡Dow-Corning Corp., Midland, Mich.

A predominately cross-linking character for the radiation induced reactions is indicated in most of these tests by an increase in modulus and a decrease in ultimate elongation. The tensile strength usually dropped. The most striking exception occurred in the case of raw natural rubber for which beneficial cross-linking reactions actually brought about a rudimentary cure. The effects were similar with raw GR-S, but were not so pronounced.

All things considered, natural rubber appeared to withstand this radiation dose better than any other of the vulcanized elastomers. Since the free radical character of the changes induced by radiation is well recognized, it is reasonable to expect that the type of compounding can affect the results. The curves in Figure 8 for two GR-S gum stocks illustrate the superiority of a sulfurless Tuads acceleration for stability against the effects of radiation as compared to a cure with Altax. This is the same type of advantage which would be expected in heat aging of the stocks where free radical mechanisms promote oxidation.

Summary and Conclusions

A survey has been made of the effects of intense gamma radiation on the physical properties of elastomers and plastics. Such information is required to determine the types of elastomers which are most resistant to radiation, to estimate the service life of elastomers exposed to radiation, and to show favorable trends in compounding for radiation resistance.

Intense radiation may affect the physical properties of elastomers beneficially or adversely, depending upon the type of elastomer and the exposure dose although hardening and embrittlement are most commonly observed. The possibility is apparent of developing elastomer compounds with improved radiation resistance, especially by the use of chemical agents which affect free radical reactions. The nature of the elastomer, however, will probably severely limit what can be accomplished by compounding.

Acknowledgment

The authors wish to express their thanks to the Goodyear Tire & Rubber Co. and H. J. Osterhof for permission to publish this work. G. K. Higgins prepared the mechanical goods compounds. The cooperation of L. E. Brownell, supervisor of the Fission Products Laboratory, University of Michigan, and his associates, in making the Co-60 source available and assisting in its use was of inestimable value and is gratefully acknowledged.

New German Finish for PVC

A difficulty still found to some extent with polyvinyl chloride sheeting and imitation leathers is the tendency of the plasticizer to migrate to the surface and cause sticky surfaces, while the goods themselves became hard and brittle.

Farbenfabriken Bayer, A.G., has found that finishes of cross-linked polymers based on a combination of its Desmophen 1200 (a polyester of adipic acid, 1,3,butylene glycol and hexane triol) and Desmodur T (toluene diisocyanate) provide a surface that is insoluble and resists swelling.

Under the name of Definal M and Definal G. K., finishing pastes are now being marketed which are used in combination with Desmodur T.

Developments in the GR-S Field Since the Advent of Cold Rubber[1]

Louis H. Howland[2]

Improvements in polymerization formulae for GR-S, including non-staining shortstops, and antioxidants, more powerful activators, and masterbatches with oil and/or pigments, developed since LTP GR-S became a commercial product, are reviewed in detail. Also included is information on the use of various heat exchangers to permit shorter reactions times.

LTP GR-S latices with adequate tensile film strength have been developed, and high Mooney viscosity polymers have been found necessary for optimum properties for some latex applications.

THE work discussed in this paper was sponsored by the Reconstruction Finance Corp., Office of Synthetic Rubber,[3] and was carried out by groups cooperating in the Government Synthetic Rubber Program. Some references, however, are cited for work in this field conducted by other organizations.

The cold rubber (LTP GR-S) development has grown until approximately 70% of all GR-S is now produced by polymerization at low temperatures. The first cold rubber produced commercially was designed for tire treads and general-purpose use. We are all familiar with the improvements in quality of vulcanizates from cold rubber, as compared to those of 122° F. GR-S. Also, we are familiar with properties where cold rubber surpasses natural rubber, such as in roadwear resistance of tire treads.

Since the original introduction of LTP GR-S, many developments have been accomplished in improving manufacture, making cold rubbers both of the general-purpose and specialty types, producing various types of masterbatches and extended products, and manufacturing cold rubber latices for various applications, including tire cord dip, foam sponge, etc. The developments in these fields, which the writer considers to be of particular importance, are included in this paper.

Recipe Development for Low-Temperature Polymerization

Numerous advances in formula development have been reported in the literature (1-6).[4] In general, work in this field on the disproportionated rosin emulsification has been directed mainly to the development of recipes that give fast polymerization rates, uniformity of reaction and of product, and do not require complicated activator make-up. The original cold rubber formulae, GR-S X-432 and GR-S X-435, contained high sugar activation, as illustrated in the first column in Table 1. The next formula had a low sugar activation, as in the second column, and was followed by a no-sugar recipe of the type shown in the third column. The no-sugar recipe is low cost and gives uniformity in plant operation. It has been used for some time in commercial polymers such as standard LTP GR-S. As indicated, the preferred recipe for a number of manufacturers and consumers is rosin acid emulsification although fatty acid or fatty acid plus rosin acids is being employed commercially as emulsifiers in numerous recipes for important polymers.

TABLE 1. LOW-TEMPERATURE RECIPES

Ingredient	High Sugar	Low Sugar	Sugar Free	SFS
GR-S	X-432	X-478	1500	X-750
Butadiene	70.0	70.0	70.0	70.0
Styrene	30.0	30.0	30.0	30.0
CHP*	0.17	0.12	—	—
PMHP†	—	—	0.08	0.06
$FeSO_4 \cdot 7H_2O$	0.15	0.14	0.16	0.018
$Na_4P_2O_7$	0.6	—	—	—
$K_4P_2O_7$	—	0.16	0.19	—
Versene‡	—	—	0.01	0.027
Dextrose	3.0	0.9	—	—
SFS§	—	—	—	0.07
Dresinate 214¶	4.5	4.5	4.5	4.5
Tamol N‖	0.1	0.15	0.15	0.15
$Na_3PO_4 \cdot 12H_2O$	0.4	0.5	0.5	0.5
MTM**	0.2	—	—	—
Sulfole B-8††	—	0.18	0.18	0.18
Water	180.0	200.0	200.0	200.0

All recipes run 12 hours at 5° C. to 60% conversion and 55 Mooney viscosity. Rates may be varied by adjusting catalyst and activator.

***Cumene hydroperoxide. Hercules Powder Co., Wilmington, Del.**

†Paramenthane hydroperoxide. Hercules Powder Co.

‡Ethylenediamine tetracetic acid sodium salt. Bersworth Chemical Co., Framingham, Mass.

§Sodium formaldehyde sulfoxylate.

¶Potassium soap of disproportionated rosin. Hercules Powder Co.

‖Condensed sodium salts of alkyl naphthalene sulfonate. Rohm & Haas Co., Philadelphia, Pa.

****Mixed tertiary mercaptans. Phillips Chemical Co., Akron, O.**

††Tertiary dodecyl mercaptan. Phillips Chemical Co.

In order to simplify the manufacturing recipe and decrease the iron compounds in it with the object of getting polymer vulcanizates with improved aging resistance and improved color both unaged and aged, a program was conducted to find an activator that required no special make-up and needed only small amounts of a combination of ferrous sulfate and a sequestering agent as a promoter (2). Such a material was found in sodium formaldehyde sulfoxylate (SFS). This was first made on a plant scale as GR-S X-750. A formula containing this activator is shown in the last column of Table 1.

This SFS recipe may be run over a wide range of reaction speeds by adjusting catalysts, activator, and promoters. The speed employed depends upon the

[1] Presented before the Wellington-Waterloo Section, Chemical Institute of Canada, at Kitchener, Ont., Canada, Nov. 10, 1953.

[2] Manager, synthetic rubber development, Naugatuck Chemical division, United States Rubber Co., Naugatuck, Conn.

[3] Federal Facilities Corp., U. S. Treasury Department, since July 1, 1954.

[4] Numbers in parentheses refer to Bibliography items at the end of this article.

ability of the system to remove heat of reaction. The quality of the polymers made by the new recipe are of at least standard quality. Some additional recipe work will be discussed under other headings.

Dithiocarbamate Salts Best Shortstops

Another feature in synthetic rubber manufacture that should be mentioned at this point is shortstopping (3, 7, 11). There are many chemicals that will stop polymerization, but considerable effort was expended before really suitable materials were decided upon for general use. Some of those that have been used most extensively in cold rubber production are as follows:

SHORTSTOPS

1. Ditertiary butyl hydroquinone.
2. Dinitrochlorobenzene.
3. Hydroquinone ± hydrogen peroxide for use in specific recipes.
4. Dimethyl dithiocarbamic acid salts (Na, K, $\begin{matrix}CH_3\\CH_3\end{matrix}\!\!\diagdown\!\!\diagup NH$)
5. Number 4 plus sodium polysulfide.
6. Number 4 plus polyethylene polyamine.

The ditertiary butyl hydroquinone (DBHQ) was first employed commercially in GR-S X-432 and GR-S X-435 cold rubbers made at the government synthetic rubber plants operated by U. S. Rubber and Copolymer Corp., respectively. The DBHQ is an excellent shortstop, but is expensive, must be made into a very fine dispersion by long grinding, and cannot be used in non-staining rubber.

Dinitrochlorobenzene next came into use because it was very effective in shortstopping action, could be added in styrene solution, and was cheap. The DNCB, was first employed in GR-S X-478 at the Copolymer Corp. operated plant at Baton Rouge, La. Professor Kolthoff (2) studied this type of chemical in emulsion polymerization. This material came into disfavor, however, because of toxicity and bad odor on hot mastication of compounds from polymer containing it when used in some of the early synthetic rubber recipes. In the polymers where DNCB caused the most trouble, which were made on the sugar-free recipes, it was found that hydroquinone or hydroquinone-hydrogen peroxide (3) functioned as a shortstop although this combination was still not satisfactory for non-staining polymers. As is well known, hydroquinone has been used for years in shortstopping 122° F. GR-S type of polymerizations, but was not effective in many cold rubber polymerizations. It was used, however, in the cold GR-S X-571 and GR-S X-572, made at the Borger, Tex., plant when it was operated by U. S. Rubber.

Since none of the above materials was entirely satisfactory, work continued for a non-toxic, water soluble, non-discoloring shortstop that could be added to a reactor without affecting later batches run in the same reactor. Such a material was found in dithiocarbamate salts, as mentioned in an article by Smith, Werner, Westerhoff, and Howland (10). The first of these used commercially was the dimethyl amine salt of dimethyl dithiocarbamic acid which was employed in GR-S X-544 and GR-S X-547 cold latices. This was followed in solid rubber formulations as GR-S X-565 (non-staining wire insulation polymer) by the corresponding sodium salt (6). Since a little coagulum is formed when a solution of this material is added to the reaction mixture, it is usually employed with an emulsifying agent in the shortstopping solution. It has since been found that the potassium dimethyl dithiocarbamate can be used in many recipes without added emulsifiers, without floc formation and, consequently, is employed in most cold GR-S latices (3).

The dithiocarbamate salts are also used by a number of producers, in combination with auxiliary shortstops such as sodium polysulfide (7) and high molecular weight polyethylene polyamines, respectively. These combinations are very effective and are employed in a large number of GR-S products. The polysulfide combination is described in an article by Antlfinger and Lufter (7) and was first used in GR-S X-610 at the Port Neches, Tex., plant operated by The B. F. Goodrich Co. The polyamine combination was first used at the Goodyear Tire & Rubber Co., operated Houston, Tex., plant in GR-S X-625 (13).

As inferred earlier, many materials have shortstopping action, but the above are the ones that have been employed in the largest quantity.

It is much easier to stop conversion than Mooney viscosity rise of a polymer during polymerization.

The behavior of increasing quantities of shortstop is illustrated in Table 2, where sodium dimethyl dithiocarbamate is employed in shortstopping a cold rubber polymerization. This shows that sometimes the conversion is stopped more readily than the Mooney viscosity increase. In this type of test, 0.05-part of the shortstop per 100 of charged monomers is required for stopping conversion and 0.075 to 0.100 for stopping the Mooney viscosity rise.

It should be mentioned that a search still continues for a more perfect shortstop from the viewpoint of such properties as cheapness, non-discoloration, and non-staining.

TABLE 2. SHORTSTOPPING OF LOW-SUGAR REDOX GR-S RECIPE WITH ADAM*

Part ADAM	% Conversion		Mooney Viscosity ML-4	
	Unaged	Aged	Unaged	Aged
0	65.0	88.5	76.0	131.0
0.025	65.0	89.0	76.0	130.0
0.050	65.0	65.6	76.0	93.0
0.075	65.0	66.4	76.0	77.0
0.100	65.0	64.6	76.0	76.0

*ADAM is sodium dimethyl dithiocarbamate.

Fast Polymerizations

Some of the early emulsion polymerizations of butadiene or butadiene/styrene, as reported from Germany, were very slow, probably owing to both purity of ingredients and to formulations. In later years, however, this situation was improved in both Germany and America. By the use of pure monomers and suitable recipes, the time of polymerization in the conventional jacketed plant reactors was 12 to 14 hours to 72% conversion. Faster rates tended to lose temperature control because of lack of cooling capacity obtained through the jackets of 3,750-gallon reactors at 90% loading. Early in the synthetic rubber program, some coil heat exchangers placed in the vapor space or extending into the vapor space of the reactors were tried in order to remove heat of reaction and thus aid in obtaining faster polymerization rates. These became fouled so quickly, however, and cleaning was so difficult that their use was abandoned. The fouling may have been due either to being in the vapor space or instability of the hot rubber latex or to both.

When LTP GR-S became established commercially, it was found that extremely fast polymerizations could be conducted with newly developed recipes provided the heat of reaction could be removed at a rapid enough

rate. As a start to study equipment for handling these fast reactions, pilot-plant installations were made in which reactors (80 and 500 gallons) were connected with external heat exchangers, and the reaction mixture was continuously pumped from the reactor through the heat exchanger back into the reactor. The temperature of polymerization was maintained on two- or three-hour reactions when sufficient heat exchange surface was used.

For preliminary work a Walker-Wallace[5] heat exchanger was employed because it could be easily dismantled for cleaning if it were fouled by unstable recipes used in the development work. This equipment is illustrated in Figures 1 and 2. The low degree of fouling that was obtained indicated, however, the commercial possibilities of heat exchangers for handling fast low-temperature polymerizations.

Next, Phillips Chemical Co. (14) used a heat exchange bundle internal to the reactor. The success of this operation caused a general adoption of heat exchangers in LTP GR-S production. There was much experimenting with heat exchanger design, however, particularly to aid in cleaning. One plant placed cooling coils completely around the inside of the reactors and abandoned jacket cooling and was able easily to control six- or seven-hour reactions. Ordinary coolant solution was first used in the heat exchangers, but later some installations employed direct ammonia expansion for cooling. The latter has proved cheap and effective. Polymerizations may now be run so fast in some of the present plants that the finishing lines become a bottleneck.

It should be mentioned that heat exchangers act as baffling devices in the reactor system and cause somewhat more power to be required for agitation.

For solid rubber manufacture (low solids latex recipes) the heat exchangers have been used for long periods of time before requiring cleaning. More recently, however, they have been employed for high solids cold rubber latex manufacture, and experience is being gained on time required with various recipes before cleaning is necessary. The use of heat exchangers in latex manufacture has been generally satisfactory.

The success of increased heat exchange surface for low-temperature polymerization and the use of the external heat exchangers, as well as some work on higher-temperature polymerizations in pipes, led to a study of continuous pipe polymerization at low temperature on a pilot-plant scale (3,15-16). Various types of installations have been employed, some giving straight-line flow and others turbulent flow. In preliminary work, our company used a Walker-Wallace heat exchanger which was equivalent to 750 feet of ¾-inch pipe. The numerous 180-degree reversals of flow in the Walker-

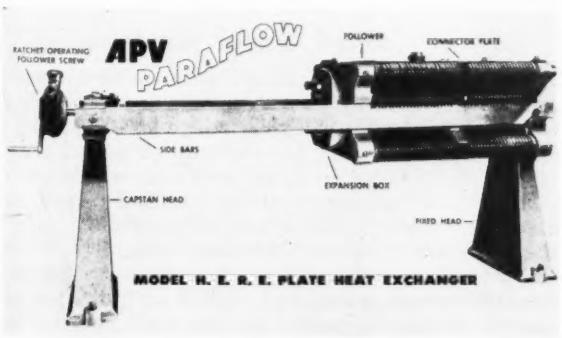


Fig. 1. Walker-Wallace Heat Exchanger Used for Fast LTP GR-S Reactions

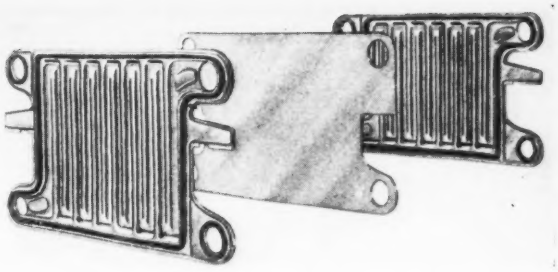


Fig. 2. Plates from Walker-Wallace Heat Exchanger

Wallace exchanger added turbulence, and polymerizations of reasonable conversion were obtained in 10 to 20 minutes. Several different types of recipes were developed for this work. Some recipes used under straight-flow conditions required considerably higher water, and higher soap than normal, and the resulting products were usually employed as polymer-emulsifier acid masterbatches.

It has been felt that continuous polymerization in pipe could be developed to give a lower-cost polymerization area than used in present plants, and also simpler operation. The advantages in this direction, however, have been cut considerably by the use of internal heat exchangers in present plant reactors for controlling fast reactions.

Further work is in progress in order to determine the benefits of fast pipeline polymerization and the quality of the product formed from such processes under various conditions of operation.

Non-Staining Cold Polymers Including Low Water Absorption Polymers for Wire Insulation and Other Applications

For numerous uses in various fields of rubber application, non-staining cold rubbers became desirable so that the improved physical properties obtained by low-temperature polymerization could be utilized in light-colored rubber goods or in rubber goods that came in contact with light-colored material in service. The earliest of these polymers were made on fatty acid and fatty acid plus rosin acid emulsification. The first of these was GR-S X-565 (6) which, with a few minor modifications, is now GR-S 1503. The recipes for these polymers utilized polyamine instead of ferrous pyrophosphate activation. The former improved the color of the polymers and gave fast uniform polymerization. Also, complicated activator make-up was not required. These products utilized the non-staining dithiocarbamates as shortstops and non-discoloring, non-staining antioxidants or stabilizers. Two of these polymers are designated GR-S 1502 and GR-S 1503. The former utilizes a styrylated phenol as the antioxidant; while the latter contains a tri alkyl phenyl phosphite. Formulations of products of these types are demonstrated in Table 3 as GR-S X-620 and GR-S X-625.

Fatty acid or part fatty acid was used in the emulsification in order to make a product that would not stick badly to calenders and other processing equipment.

In addition to other characteristics, the GR-S 1503 is a low water absorption polymer that may be used in wire insulation and other places where this property is desirable. The low water absorption is obtained by glue-acid instead of brine-acid flocculation and subsequent squeezing of the wet coagulum with a tuber to remove the serum. This is followed by thorough washing.

[5]Walker-Wallace, Inc., Buffalo, N. Y.

TABLE 3. RECIPES FOR NON-STAINING COLD POLYMERS

Ingredient	Polyamine Activated X-620	Iron Activated X-625
Butadiene	70	70
Styrene	30	30
PMHP	0.10	0.08
DETA*	0.12	—
$FeSO_4 \cdot 7H_2O$	0.002	0.16
$K_4P_2O_7$	—	0.19
Versene	0.004	0.01
Potassium fatty acid soap	4.7	2.25
Dresinate 214	—	2.25
Tamol N	0.15	0.15
KCl	0.4	—
$Na_3PO_4 \cdot 12H_2O$	—	0.6
Sulfole B-8	0.18	0.18
Water	180-200	180-200
Shortstop (dithiocarbamate)	0.1	0.1
Stabilizer (Polygard type)†	1.25	—
(Wingstay S type)‡	—	1.25
Flocculation	Glue-acid	Salt-acid

All recipes run 12 hours at 5° C. to 60% conversion and 55 Mooney viscosity. Rates may be varied by adjusting catalyst and activator.

*Diethylene triamine. Carbide & Carbon Chemicals Co., New York, N. Y.

†Alkylated aryl phosphite. Naugatuck Chemical.

‡Styrenated phenol. Goodyear Tire & Rubber Co., Akron, O.

A low styrene variety of GR-S 1503 will be discussed later.

In addition to these non-staining products, several non-staining oil masterbatches of LTP GR-S have been made. The three most active products of this type are presented in Table 4.

TABLE 4. NON-STAINING OIL MASTERBATCHES OF COLD GR-S

GR-S 1703	25 parts naphthenic oil—mixed acids—60 ML-4
GR-S 1707	37.5 parts naphthenic oil—rosin acid—55 ML-4
GR-S 1708	37.5 parts naphthenic oil—fatty acid—60 ML-4

The GR-S 1708 was originally GR-S X-718 and is related to GR-S 1503; while the GR-S 1703 is related to GR-S 1502. These base polymers were discussed above. The polymer in these non-staining oil masterbatches, of course, is of higher Mooney viscosity so that with the oil present, the final Mooney viscosity is in the processable range. The GR-S 1707 is related to GR-S 1500 (standard LTP-GR-S) and therefore is made on disproportionated rosin acid emulsification. The rosin-type emulsifier is considered advantageous since it tends to overcome the dryness imparted by the oil.

Numerous applications are developing for these materials.

Concerning the future, a search that is showing success is being made for a better low-cost non-discoloring, non-staining oil for use in masterbatches of the above types, and when such material is introduced, it is believed that consumption of non-staining oil masterbatches will increase considerably.

Non-staining GR-S polymers in general constitute about 25% of all GR-S production.

Polymers for Low-Temperature Service

For the purpose of this discussion "polymers for low-temperature service" refer to elastomers that function better than natural rubber when used in finished rubber goods subjected to very low temperatures. These are sometimes called Arctic polymers.

It has been known for a long time that polybutadiene made at 122° F. polymerization temperature, when used in vulcanizates, gave a lower brittle point (17) than did natural rubber or any other elastomer from diene polymerization (Table 5). The physical properties of such vulcanizates were too poor, however, for many applications (18-19). It was found that the physical properties could be improved with some sacrifice in low-temperature properties by copolymerizing with a little styrene or similar material, or polymerizing at as low a temperature as 41° F. In the latter case the structure of the polybutadiene is improved to the point that it crystallizes too readily on standing at low temperature (20-22).

TABLE 5. THE EFFECT OF BUTADIENE/STYRENE RATIO AND POLYMERIZATION TEMPERATURES ON LOW- AND ORDINARY-TEMPERATURE PROPERTIES

Polymerization temp., ° F.	122			41		
BDE/sty. ratio	100/0	85/15	71/29	100/0	85/15	71/29
Tensile (psi.)	1520	2600	3300	2920	3650	3780
Flex crack growth (0.001" kc.)*	6.4	1.8	2.0	0.4	0.8	0.8
Heat build-up (° F.)†	75	75	70	85	76	75
Brittle point (° C.)‡	−72	−66	−57	−74	−65	−57
Torsional modulus, T_{10}§ (° C.)(23)	−71	−54	−42	−65	−50	−41

*Grooved ½- by 3-inch pierced sample 67-degree bend, 18 kc. per hour.

†Goodrich flexometer. Method A—ASTM, D623-52T.

‡ASTM D746-447.

§Temperature at which torsional modulus is 10 times that at 25° C.

In order to break up the regularity of the polybutadiene structure, it has been found that the polymer should contain about 12% bound styrene or other suitable monomer (24). GR-S 1504 is such a polymer and is illustrated in Table 6. It is like GR-S 1503 mentioned earlier except for 12% instead of 23.5% bound styrene. It is also designed for low water absorption. Another cold polymer for low-temperature service shown in Table 6 is GR-S 1505. Unlike GR-S 1504, it has a staining-type antioxidant, only 8% bound styrene, and is made on rosin soap emulsification. It is related to GR-S 1500 (standard LTP GR-S) except for low styrene content and was devised mainly for tire use. The low-temperature properties in vulcanizates from this product or other low-styrene GR-S polymers can be adjusted to some extent by blending, during compounding, with standard LTP GR-S or other GR-S polymers to give the desired styrene ratio for the finished product.

TABLE 6. 41° F. GR-S POLYMERS FOR LOW-TEMPERATURE SERVICE

Bound Styrene%	Activation	Emulsifier	Stabilizer	Finishing	Mooney Viscosity
		GR-S 1504			
12	Peroxamine*	Fatty acid	Polygard type	Special with glue-acid	52
		GR-S 1505			
8	Ferrous sulfate	Rosin acid	PBNA or BLE	Salt-acid	40

*Organic hydroperoxide catalyst—polyethylene polyamine activator.

Softener-Synthetic Rubber Masterbatches

A synthetic rubber such as a GR-S made to a Mooney viscosity in the easily processable region such as 50 is composed of a high molecular weight fraction and a smaller amount of very low molecular weight fraction (Figure 3) (25-26). The latter in some cases amounts to about 25% of the polymer and is roughly one-tenth the molecular weight of the high molecular weight fraction and is extractable from the total GR-S with methyl ethyl ketone. This low molecular weight fraction results from the modifier cutting short a number of the growing molecules in the polymerization. The quantity of this fraction depends on numerous factors including amount and type of modifier, ingredients in the polymerization recipe, conversion, and temperature of polymerization.

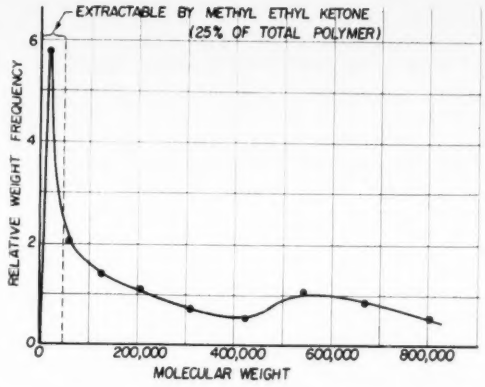


Fig. 3. Distribution of Molecular Weights in 122° F. GR-S

Studies of the relation between the molecular weight of a raw GR-S polymer and the physical properties of the corresponding vulcanizate have been made by Yanko (27) and Johnson (28), who separated GR-S into fractions of varying molecular weight by precipitation from solution. Yanko's work showed that fractions of low molecular weight give vulcanizates in a tread-type recipe which are considerably inferior in tensile strength, ultimate elongation, and flex-life, and somewhat inferior in rebound to a vulcanizate of unfractionated GR-S. The unfractionated polymer, in turn, was inferior in these properties to the fractions of high molecular weight. For example, the values for tensile strength at comparable moduli were 1,100, 2,940, and 4,750 psi., corresponding to molecular weights of 23,600, 96,500 (unfractionated), and 1,650,000.

While Yanko prepared and tested nine separate fractions, Johnson obtained only three, but on a much larger scale, and was able to prepare sections of tire treads for tests of resistance to abrasion and crack growth. The high molecular weight fraction was found to be 13% superior to the unfractionated control in abrasion resistance, and 23% better than a 50-50 mixture of the low molecular weight fraction with unfractionated GR-S. (It was necessary to test the material of low molecular weight as a mixture, since it was otherwise too soft to process.)

Johnson also found that the fraction of high molecular weight was almost three times as resistant to crack growth as the unfractionated control, or the 50-50 mixture.

Yanko found that the fraction which had a number average molecular weight of 103,400, compared with 96,500 for the unfractionated control, when tested in vulcanizates, was essentially equivalent to this control in rebound and resistance crack growth, while the former was superior in tensile strength.

More recently Beatty and Zwicker (29) reported on a large-scale fractionation of GR-S and have come to the same general conclusion.

When polymers containing low molecular weight material are vulcanized, a lot of loose ends are believed to be left which are thought to be detrimental to many physical properties of vulcanizates such as hysteresis (29). The question immediately arises as to whether this low molecular weight fraction could not be replaced advantageously by some cheap organic softener not related chemically to the rubber and probably of a non-vulcanizing character. A method of accomplishing this replacement which has recently been developed, is to prepare a polymer such as GR-S to a high Mooney viscosity, and after shortstopping and removing unreacted monomers, but while it still is in the latex state, adding a colloidal suspension of the desired organic softener in a quantity necessary to give optimum rubber quality. This is usually accomplished with 20-50 parts of the added material.

One property required of the additive is non-volatility under the conditions of fabrication. This also applies to service conditions.

The resulting composition, which in the trade is called a masterbatch, is frequently compounded as though it were 100% vulcanizable rubber. Much of the material, however, is used in blends with other rubbers and is not employed on a 100% basis.

One type of extender that was studied at an early date and has given commercial products is lubricating or mineral oil. An article (30) describing work in this field has been published by D'Ianni and Hoesly, of Goodyear, and Greer, of OSR. Other literature on this subject (31-32) has also appeared.

Several of the products made in government plants and sold to the trade are shown in Table 7. The non-discoloring modifications were illustrated earlier (Table 4).

TABLE 7. OIL MASTERBATCHES OF COLD GR-S

GR-S 1704	25 parts aromatic oil—rosin acid—60 ML-4
GR-S 1705	25 parts aromatic oil—mixed acids—60 ML-4
GR-S 1706	25 parts highly aromatic oil—mixed acids—60 ML-4
GR-S 1709	37.5 parts aromatic oil—rosin acid—55 ML-4
GR-S 1710	37.5 parts aromatic oil—mixed acids—55 ML-4
GR-S 1711	37.5 parts highly aromatic oil—rosin acid—55 ML-4
GR-S 1712	37.5 parts highly aromatic oil—mixed acid—55 ML-4

Production and Use

The total volume produced and the trend from July, 1952, to October, 1953, are shown in Figure 4.

Oil masterbatches are used in many products such as tire treads, tire carcass, heels and soles, etc. These products not only help to reduce cost, but give some superior properties to vulcanizates such as decreased heat build-up in tires. Also, the abrasion resistance of tire treads may range from approximately equal to better than that from standard cold rubber treads, depending on the conditions of service. Typical properties are illustrated in Table 8.

New Developments

Many other types of materials have been investigated, only a few of which will be mentioned here. One that has been reported in the literature (36) and has been produced to date in only one large-scale experimental GR-S materbatch is the rosin type in cold GR-S. This is made by adding a selected rosin soap to the latex in the de-

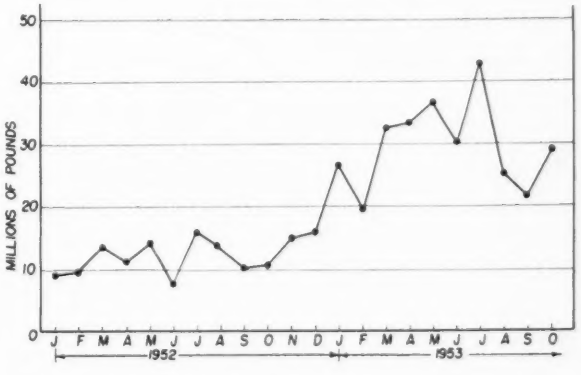


Fig. 4. Production of GR-S Oil Masterbatches in 1952 and 1953

sired quantity and flocculating and finishing in the usual manner. It can be suitably flocked, however, with such materials as zinc or magnesium salts which aid in giving non-blooming vulcanizates. When salt-acid flocculating is employed, sufficient zinc oxide must be used in compounding in order to prevent rosin bloom from the resulting vulcanizate (37). Properties of a tread vulcanizate are shown in Table 9.

TABLE 8. PROPERTIES OF AN OIL EXTENDED COLD GR-S IN A TREAD STOCK

Polymer No.	A	B
Polymer	80	100
Oil	20	—
HAF black	50	50
300% Modulus, psi	1780	1730
Tensile, psi	3080	3400
205° F. tensile, psi.*	1070	1340
Aged tensile, psi.†	2860	3240
Heat build-up, °F.	41	64
Torsional hysteresis (34)	0.081	0.094
Rebound, %‡	44	46
Constant slip abrasion rating (35)	103	100

*ASTM D412-51T.
†ASTM D412-51T, after aging 96 hours in air oven at 212° F.
‡Bashore resiliometer.

TABLE 9. PROPERTIES OF A DISPROPORTIONATED ROSIN COLD GR-S MASTERBATCH IN A TREAD STOCK

Polymer No.	A	B
Polymer	75*	100†
Resin 731‡	25	—
HAF Black	55	55
Compound viscosity—ML-4	81	80
300% Modulus, psi.	2010	2200
Tensile, psi.	3730	3230
205° F. tensile, psi.	2110	1700
Aged tensile, psi.	3740	2850
Heat build-up, °F.	61	73
R. T. rebound, %	25	48
Flex crack growth, 0.001"/kc.	0.3	1.1
Constant slip abrasion rating	160	100

*Cold rubber (ML-4 110).
†Standard cold rubber (ML-4 50).
‡Disproportionated rosin. Hercules Powder Co.

TABLE 10. PROPERTIES OF A DIOCTYL AZELATE-COLD GR-S MASTERBATCH IN A TREAD STOCK

Polymer No.	A	B*
Polymer	75	100
Dioctyl azelate	25	—
HAF black	50	50
Compound viscosity—ML-4	54	70
300 Modulus, psi.	1790	1730
Tensile, psi.	2730	3400
205° F. tensile, psi.	930	1160
Heat build-up, °F.	38	70
R. T. rebound, %	51	46
Flex crack growth, 0.001" kc.	1.7	1.5
10% Retraction at °F. (24)	−87	−61
70% Retraction at °F. (24)	−67	−36
Abrasion rating	103	100

*Standard LTP GR-S.

In general, in a carbon black reinforced stock, the rosin masterbatches give improved unaged and aged tensile strength, lower heat build-up, improved flexing resistance, but inferior room-temperature resilience, as compared to similar stocks from standard cold GR-S. Also, with suitable compounding and under certain conditions of service, these products give treads with considerably improved resistance to road wear.

A more expensive product that gives interesting masterbatches is dioctyl azelate. These are made similar to oil masterbatches. Some test results are shown in a tire tread stock in Table 10. It is noted that the extended stock, although it has lower tensile strength, gives considerably improved resistance to heat build-up and somewhat superior resilience and shows equivalence in flexing resistance and abrasion rating when compared to a corresponding standard cold rubber stock. In addition to other properties, this plasticizer helps in products used in low-temperature service.

Two or more extenders have been incorporated into the same masterbatch. In this connection, oil-plus rosin extension in high Mooney viscosity, cold GR-S has given interesting masterbatches in that they give rubber compounds that are not too dry or too sticky and handle quite well in calendering operations. Somewhat similar results can be obtained, however, by blending oil and rosin masterbatches.

Masterbatches of Cold Rubber with Pigment and Pigment Softener

Carbon Black

In view of the success of carbon black masterbatches of 122° F. GR-S, it was only natural to develop and use cold rubber masterbatches of carbon black with and without added softener. The carbon black masterbatches, not including oil-black-polymer masterbatches, now amount to about 15% of total LTP GR-S solid polymer production. Approximate quantities of production of these materials over the last several years are shown in Figure 5.

Carbon Black Masterbatches

Masterbatches as the standard GR-S 1600 containing HAF black are made in the usual manner (38). The black is ground in a micropulverizer and mixed in water with Marasperse CB[6] dispersing aid to give a fluid slurry of about 20% solids, and this in turn is mixed with cold latex containing a polymer of 50 Mooney viscosity or lower to give a mixture termed "carbex" (mixture of *carbon* black slurry and lat*ex*). This is flocculated, washed, and dried. The best dispersion of black in finished polymer is obtained by shock coagulation (39), that is, running brine and acid into the latex simultaneously. Adding brine before the acid, flocculates the black before the rubber; whereas shock coagulations flocculate both at the same time and thus give a good dispersion of carbon black in the polymer.

It has been shown that homogenization of the "carbex" in a Waring Blendor (10,000 rpm.)[7] or a pilot-plant Entoleter[8] (14-inch disk at 3,600 rpm.) gives improved dispersion of carbon black which results in 6-9% improvement in tire tread wear (39).

In addition to improved carbon black dispersion, the use of a homogenizer, as described above, gives a porous crumb in "carbex" flocculation which floats, is easy to wash and to recover in high yield, and dries faster than masterbatch crumb prepared by the standard procedure. This results in increased production per hour from a drier.

The Entoleter has been used on a pilot-plant scale, instead of the usual micropulverizer, for depelletizing HAF black for preparing slurries for latex masterbatching. Dry grinding has been employed. Both one pass and two passes have been used, with one pass giving almost as good results as two passes.

More recently, HAF carbon black has been depelletized by a steam jet process; then the resulting slurry without dispersing agent has been homogenized with

[6]Sodium salt of partially desulfonated lignin sulfonate. Marathon Corp., Rothschild, Wis.
[7]Waring Products Corp., New York, N. Y.
[8]Safety Car Heating & Lighting Co., New Haven, Conn. United States patent No. 2,658,049 covers use in masterbatching.

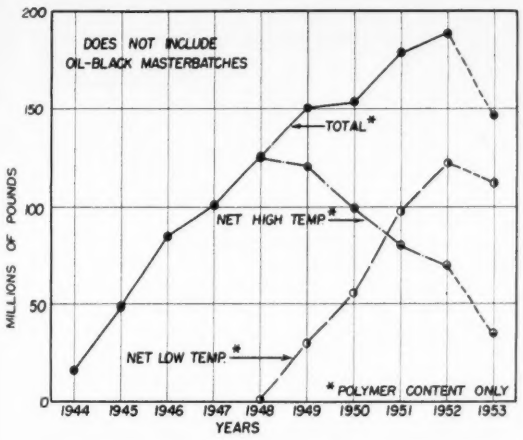


Fig. 5. Production of GR-S Carbon Black Masterbatches, 1944-1953

cold rubber latex in another steam jet, as described by Copolymer Corp, Baton Rouge, La. (40) Tire treads from this-type masterbatch, in preliminary tests, have indicated some improvement in tire tread wear. This is being checked with new preparations and new tests.

Excellent HAF black-cold rubber masterbatches with improved carbon black dispersion have also been obtained on a development scale by the latex procedure, using black slurries made by collecting the smoke directly in water, with or without a dispersing agent such as Marasperse CB present in water. These have been made with both HAF and SAF black types. Such masterbatches have given tire treads which have indicated improved resistance to wear.

Masterbatches have been made with various carbon blacks such as EPC, MPC, SRF, HAF, and SAF by various procedures. Considerable quantities of masterbatches are used to avoid mixing in black or because of shortage of mixing equipment in a fabricating plant rather than for quality reasons.

The most active carbon black-cold rubber masterbatches are shown in Table 11.

TABLE 11. BLACK MASTERBATCHES OF COLD GR-S

GR-S	Black to 100 of GR-S	Mooney Viscosity (ML-4) of Polymer	Emulsifier	Stabilizer
1600	50 (HAF)	50	Rosin type	Staining
1601	50 (HAF)	36	50/50 Rosin/fatty acid	Staining
1602	50 (HAF)	50	50/50 Rosin/fatty acid	Staining

Carbon Black-Softener Masterbatches

These GR-S/carbon black/oil masterbatches were made originally by mixing an oil emulsion, a black dispersion, and cold rubber latex and flocculating and finishing by the usual methods for carbon black materbatching (32). Many procedures including homogenization have been used on a pilot-plant scale to make these three component masterbatches. A very successful economical procedure for this operation is to disperse the carbon black as usual, but with excess caustic present; then while stirring, mix in oil containing a small amount of dissolved oleic acid (41). This oil emulsifies as the oleic forms soap with the caustic.

Masterbatches of this type must be made from sufficiently high Mooney viscosity polymer so that masticating gives sufficient shearing force to disperse black agglomerates in the rubber compound. This improved dispersion results in obtaining maximum vulcanizate properties. Carbon black-softener masterbatch is available under the designation GR-S 1801.

Non-Black Fillers

Development work has resulted in interesting masterbatches of cold rubbers with pigments other than carbon black, of the inorganic type such as Hi-Sil[9] and some organic resinous pigments such as Indulin.[10]

Latex

Although 122° F. GR-S latices found many uses, latices containing polymers of greater strength were needed for many applications. Low-temperature polymerization offered the opportunity to realize this requirement. Whereas 122° F. latices were usually carried to as near complete conversion as possible, the LTP latices were carried to lower conversions of 60 to 80% in order to prevent branching and cross-linking of the polymers and to obtain the best possible properties from articles made from the latices. This low conversion has made it difficult to polymerize a latex directly to solids above 50%. In order to obtain 60% solids products, both creaming and heat concentration were studied, and heat concentration was chosen as the more satisfactory procedure (10). The flow diagram for the first commercial procedure is illustrated in Figure 6. The Walker-Wallace heat exchanger is the same as described under "Fast Polymerizations." Also, (42) a Turba-Film evaporator[11] has been developed for concentrating GR-S latices on a pilot-plant scale, and its possibility for commercial use looks good.

Many applications of the latices have required high Mooney viscosity (43-44) polymers in order to obtain maximum properties. This requirement has caused some instability during manfacture in the synthetic rubber plant. The high solids latices tend to go through a viscous period which is accompanied by instability. Apparently, with recipes to date, low Mooney viscosity particles agglomerate at this stage, thus decreasing the particle area to the soap; while the high Mooney viscosity particles do not agglomerate at a sufficient rate to alleviate the instability, and thus prefloc forms. This floc problem is very troublesome, but has been controlled

[9] A fine silica. Columbia-Southern Chemical Corp., subsidiary of Pittsburgh Plate Glass Co., Pittburgh, Pa. Masterbatch mentioned in U. S. patent No. 2,616,860.

[10] Lignin. West Virginia Pulp & Paper Co., Charleston, S. C. Technical Bulletin No. 113A, July, 1953, by above company, more recently in *Chem. Eng. News*, July 5, 1954, p. 2719.

[11] Rodney Hunt Machine Co., Orange, Mass.

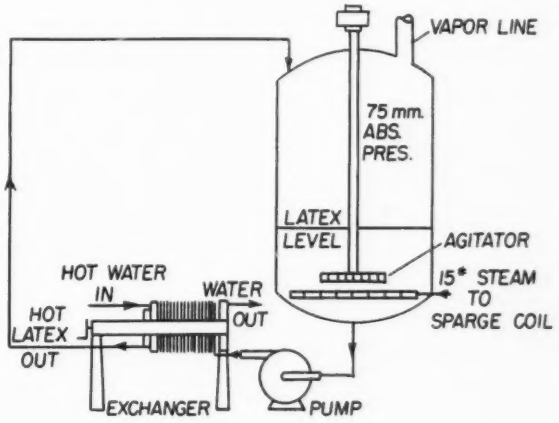


Fig. 6. Flow Diagram for Heat Concentrating GR-S Latices, Using Heat Exchanger

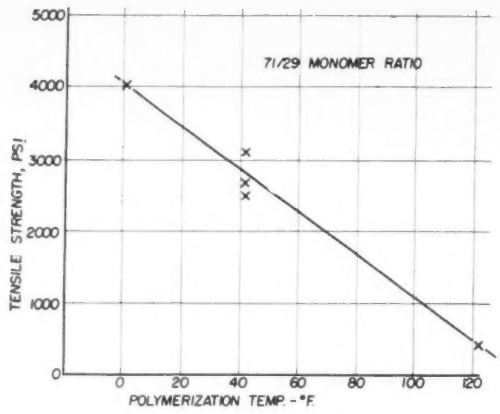


Fig. 7. GR-S Latex Film Strength vs. Polymerization Temperature

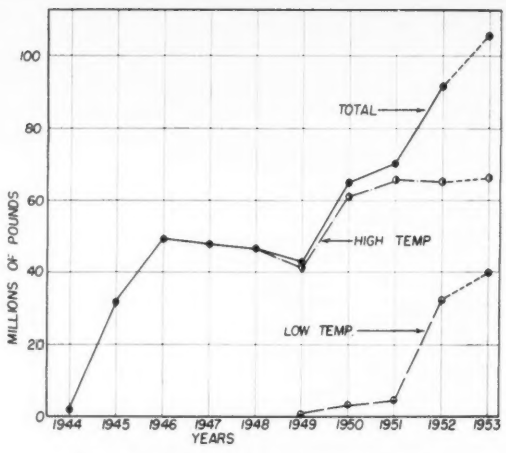


Fig. 8. GR-S Latex Production—1944-1953

fairly well by careful attention to such factors as (*a*) 45- to 55-hour reaction time, (*b*) constant reaction rate, (*c*) low initial soap, (*d*) high electrolyte, (*e*) increment addition of emulsifiers plus electrolyte, and (*f*) control of speed of agitation.

Cream formation has also been a problem in high solids latices, but this can be minimized or eliminated by a number of factors, one of the most important of which is correct increment additions of the stabilizing soap. LTP GR-S latices give cast film tensiles as high as 3,600 psi. compared to corresponding films from 122° F. GR-S latices at 300 to 500 psi. (45). Some tensile results are illustrated in Figure 7. Also, in uses such as sponge where static cracking under tension is a problem, the LTP GR-S latex sponge is many times better than the corresponding product from 122° F. GR-S latex and approaches natural rubber sponge in this respect.

There are a number of LTP GR-S latices in production. The main ones at present are shown in Table 12.

TABLE 12. COLD LATICES

GR-S	% Bound Styrene	% Solids	Emulsifier	Mooney Viscosity-Polymer	% Conversion	Activation
2100	25	49	Rosin-fatty acid	100 ML-4	60	Iron complex
X-617	25	25	Fatty acid	85 MS-4	60	Polyamine
X-619	25	60	Rosin-fatty acid	140 ML-4	60	Iron complex
X-633	45	49	Fatty acid	85 ML-4	80	Polyamine
X-667	14	60	Fatty acid	85 MS-4	60	Polyamine
X-684	25	60	Rosin-fatty acid	140 ML-4	60	Polyamine
X-710	25	58	Fatty acid	140 ML-4	70	Polyamine
X-711		60	Fatty acid	80 MS-4	60	Polyamine
X-734	23.5	25	Rosin acid	52 ML-4	60	Iron complex
X-758	25	60	Rosin-fatty acid	140 ML-4	60	SFS
X-760	25	48.50	Rosin-fatty acid	140 ML-4	60	SFS
X-765	23.5	38-41	Fatty acid	85 MS-4	60	Polyamine

LTP GR-S latex has reached approximately 40% of total GR-S latex consumption, and its use is expected to increase still further.

The use of GR-S latex in general has been steadily increasing, as shown by the trends in production indicated in Figure 8. Consumption has been as high as 10,000,000 pounds a month.

Summary and Conclusions

Work carried out since the development of cold rubber (LTP GR-S) by groups cooperating in the U. S. Government Synthetic Rubber Program, sponsored by the Reconstruction Finance Corp., Office of Synthetic Rubber, as well as elsewhere, has been reviewed.

Development work on polymerization recipes since the first high-sugar cold rubber formulae has resulted in low-sugar and sugar-free iron pyrophosphate activated systems, polyamine activators using only a trace of uncomplexed iron, and, most recently, a low-iron, sulfoxylate activated recipe. Considerable development has also taken place in the shortstop field, resulting in the use of the non-discoloring, water soluble dithiocarbamates or their combinations with polysulfides or polyamines.

The development of very fast polymerization recipes, coupled with engineering studies on heat exchange systems, has shown the feasibility of employing conventional heat exchangers or pipeline polymerizers for preparation of LTP GR-S, in very short reaction cycles. An outgrowth of this work has been the use of internal heat exchangers in the present plant reactors allowing successful control of six or seven hours' reactions.

Non-discoloring polymers have been made possible by the use of the dithiocarbamate shortstops and non-discoloring, non-staining antioxidants; such polymers have been placed in commercial production. Special processing techniques have allowed the production of low water absorption polymer for use in the wire and cable industry. Low-styrene rubbers have been developed for articles subjected to extremely low-temperature service.

A major development in GR-S technology has been made by the incorporation of relatively large amounts of low-cost oils into high-viscosity polymers. The resulting masterbatches are easily processable and have vulcanizate properties about equivalent to those of standard cold rubber. These oil masterbatches have been widely accepted commercially. In some applications the use of rosin acid-type extenders has given greatly improved properties. Three component masterbatches of polymer, carbon black, and extender have been developed. Homogenization on a pilot-plant scale of standard latex-carbon black masterbatches by violent agitation has resulted in tire treads with improved wear resistance. Steam jet dispersion and use of carbon black collected directly in water from the burners have also indicated improved tire wear.

LTP GR-S latex gives a cast film vulcanizate with a tensile of 3,000 psi., compared to 300-500 psi. for similar 122° F. GR-S latex films. High Mooney viscosity polymer has been found necessary for optimum properties in some latex applications. The high Mooney viscosity

(*Continued on page 717*)

Application of Adiabatic Techniques To Polyethylene Extrusion—II[1]

E. C. Bernhardt[2] and J. M. McKelvey[3]

THIS installment concludes the article, begun in our July issue, which demonstrates that polyethylene extrusion under near-adiabatic conditions can be obtained in practice, and that the adiabatic melt extrusion theory can serve as a semi-quantitative guide to the design of extruders for operation with mostly mechanical power as well as for the analysis of the performance of existing extruders.

Discussion of Results

Internal Screw Heater

Previous experiments had shown that the relatively short compression zones of the screws were unable to melt and push forward polyethylene as fast as the metering zone could pump the molten material through the die. This effect was particularly noticeable at low extrusion pressures where back flow is small and the capacity of the metering zone is high. Under these conditions the extrusion rate was severely limited by the capacity of the compression zone. We found that this limitation could be overcome by heating the screw at the compression zone, and we installed a 600-watt cartridge heater in the core of each screw. Experiments showed that the performance of the extruder operating at low die pressure could be drastically changed by varying the voltage applied to this internal screw heater.

Fig. 3 is a plot of some of the performance data obtained during experimentation with the screw heater using screw 2-X-2. During the first 80 minutes of operation full voltage was applied. For an initial 40-minute period the extrusion rate slowly decreased as the extruder approached and reached thermal equilibrium. Operation was then continued for about 40 more minutes, during which time the extrusion rate, the die pressure, the temperatures, and the power consumption remained constant. The extrusion rate during this equilibrium period was about 195 grams a minute.

After about 80 minutes of operation, the power to the heater was cut off. An immediate and rapid drop in the extrusion rate was observed, and within just a few min-

[1] Based on a paper presented at the National Technical Conference, Society of Plastics Engineers, Inc., Toronto, Ont., Canada, Jan. 29, 1954.
[2] Polychemicals department, E. I. du Pont de Nemours & Co., Wilmington, Del.
[3] Formerly with du Pont, now with ChemSearch, Inc., 4701 York Rd., Baltimore 12, Md.

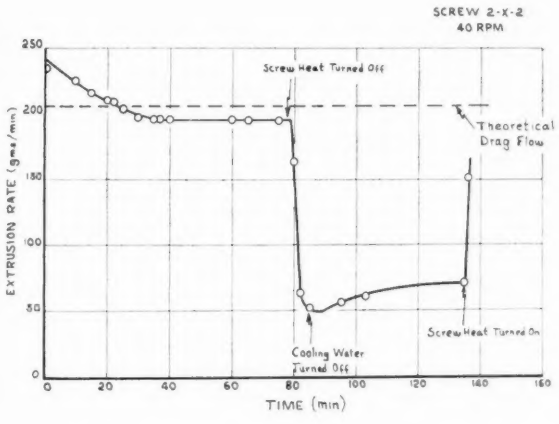


Fig. 3. Plot of Performance Data with Screw 2-X-2, Showing Effect of Internal Screw Heater on Extrusion Rate

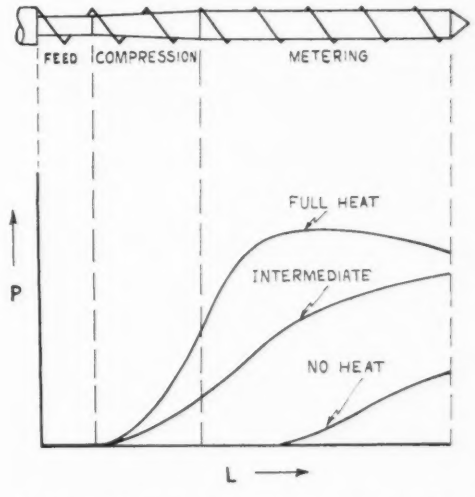


Fig. 4. Relations of Screw (2-X-2) Zones and Stock Pressures at Various Internal Screw Heater Temperatures. P Is Stock Pressure, and L Is Screw Length

TABLE 2. TEST PERFORMANCE DATA OF EXTRUSION SCREWS

Run No.	Screw	Die	Screw Speed, Rpm.	Volumetric Extrusion Rate (Q) (In^3/Sec)	Extruder Temp. (°C.)	Die Press. (Psi.)	Input Power (Watts)	Output Power (Watts)	Heat Loss (Watts)	% of Applied Power by Mechanical Working	Power Economy (Lbs/HP-Hr)
1	2-X-1	1	70	0.095	253	2750	1590	920	740	77	4.5
2		2	70	0.155	203	2600	1970	1290	440	94	5.9
3		3	70	0.290	159	2040	2620	1990	460	93	8.3
4		4	70	0.343	145	1470	2690	2200	420	92	9.5
5		5	70	0.495	119	1200	3240	2800	290	94	11.4
6		6	70	0.593	107	500	3340	2480	1050	95	13.2
7		1	150	0.215	276	3170	3750	2130	1160	97	4.3
8		2	150	0.390	228	2950	3990	3520	170	93	7.3
9		3	150	0.619	185	2170	5410	4710	390	99	8.5
10		4	150	0.770	155	1760	5620	5230	110	96	10.2
11		5	150	0.951	128	1400	6560	5550	740	97	10.8
12		6	150	1.28	112	600	7100	6200	1090	97	13.5
13	2-X-2	2	70	0.253	195	3200	2700	2040	430	92	7.0
14		3	70	0.362	180	1900	2790	2750	40	85	9.7
15		4	70	0.410	170	1250	3000	2940	330	83	10.2
16		2	150	0.575	225	3500	5510	5100	340	92	7.8
17		3	150	0.722	197	2100	5950	5800	70	92	9.1
18		4	150	0.795	185	1450	6340	6030	440	91	9.4
19	2-X-3	3	70	0.191	203	1300	2220	1570	540	90	6.4
20		4	70	0.218	199	780	2270	1740	660	86	7.2
21		3	150	0.433	245	1320	4560	4030	510	92	7.1
22		4	150	0.466	235	800	4200	4180	190	88	8.3
23		3	70	0.210	248	1000	1820	1970	890	57	8.6
24		4	70	0.234	240	600	2200	2100	570	66	7.9
25		3	150	0.438	264	1200	4610	4200	600	81	7.1
26		4	150	0.460	260	650	4550	4320	560	80	7.9

utes the extrusion rate fell to about 50 grams a minute and began to level off and approach a second equilibrium position.

At this point an attempt was made to push the extrusion rate back to its original equilibrium position by increasing the temperature of the barrel near the compression zone. To do this, the cooling water was cut off. The barrel temperature at the compression zone then rose, but the effect on the extrusion rate was quite small, as the curve in Figure 3 shows.

To demonstrate that the screw heater was the controlling factor, full voltage was again applied. The extrusion rate immediately began to climb. Eventually it again leveled off at an equilibrium position identical to the original one. Further experiments showed that by applying intermediate heater voltages, intermediate extrusion rates would be obtained.

This very interesting and pronounced effect is caused primarily by the performance of the compression zone of the screw. During these experiments pressure measurements were made at all positions along the length of the barrel and from these measurements pressure profiles were constructed, as shown in Figure 4.

These profiles throw a great deal of light on the heater effect. First, when no heat is applied to the screw core, the compression zone of the screw operates at a greatly reduced efficiency. At this low efficiency the capacity of the compression zone to melt and convey polyethylene is much lower than the capacity of the metering zone to pump the molten material. Consequently the screw channel in the metering zone does not become completely filled with molten plastic, except for a short length close to the end of the screw. Therefore only a small portion of the metering zone is being utilized to build pressure. This is shown by the "No Heat" curve in Figure 4. Under these conditions, insufficient pressure or driving force is generated to push the melt out through the extrusion die, except at a very low rate.

The condition, when full voltage is applied to the screw heater, is just the opposite. The capacity of the compression zone to melt plastic becomes greater than the pumping capacity of the metering zone, and the metering zone actually acts as a restriction to the forward flow of plastic. Consequently, the maximum melt pressure in the screw channel is not at the tip, but occurs somewhere shortly after the compression zone. The pressure decreases gradually from this position toward the die, and the pressure flow, in this case, is a forward and not a reverse flow. This is the reason why extrusion rates higher than the theoretical drag flow of the metering zone are sometimes observed. The "Full Heat" curve in Figure 4 shows the shape of the pressure profile that is obtained when the screw is acting in this manner.

The "Intermediate" curve in Figure 4 shows the shape of a pressure profile when the screw heater voltage has been adjusted to some intermediate value so that the capacity of the compression zone just matches the capacity of the metering zone. In this case the pressure buildup occurs gradually over the entire length of the screw. In our experimental program, the screw heater voltage was always adjusted so that the compression-zone capacity was equal to, or greater than, the metering-zone capacity.

When the screw heater is turned on, is the increase in capacity of the compression zone caused by increased mechanical working, or does the capacity go up merely because an additional amount of heat is available for transfer into the polyethylene? We feel that it is probably a combination of both. For example, in the run shown in Figure 3, the heater voltage was changed from 0 to 135, causing the melting capacity of the compression zone to increase by about 145 grams a minute (19.2 pounds an hour). Assuming that the polyethylene enters the compression zone at 40° C. and leaves at 120° C., approximately 900 watts are required for this capacity increase. The heater is rated at 600 watts at full load, but not all of the 600 watts can enter the compression zone, as about two-thirds of the heater is located in the metering zone of the screw. We therefore, estimate that perhaps 200 watts were available for transfer to the polyethylene in the compression zone. This accounts for only about 25% of the total power required for the observed increase in capacity; so we do not believe that the increased capacity can be explained *only* as an increase in transferred heat.

Adiabatic Performance

The performance data of the three screws have been summarized in Table 2. Extrusion rate, temperature, power, and pressure data were obtained for each of the screws at two different speeds, 70 and 150 rpm. Since the effect of die resistance is most pronounced with the deep flighted screw, all six extrusion dies were used with screw 2-X-1; dies 2, 3, and 4 with screw 2-X-2; and dies 3 and 4 with screw 2-X-3. The very smallest dies would have generated excessive pressures if they had been used with the shallow flight screw.

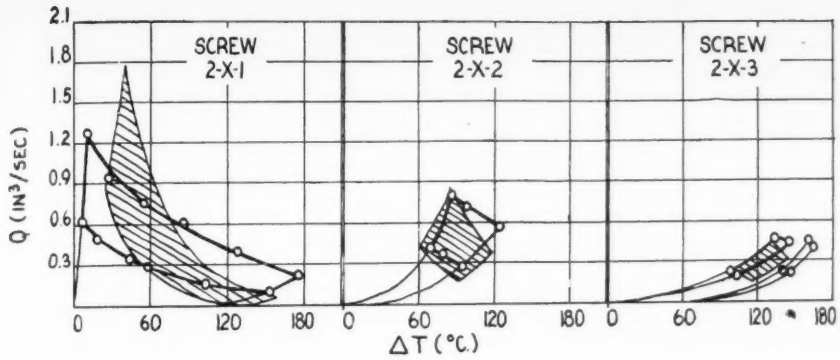


Fig. 5. Adiabatic Performance Data for Experimental Screws. Q Is Extrusion Rate, and △T Is Temperature Rise of the Molten Plastic. Shaded Portions Show Theoretical Performances Derived from Theoretical Equations

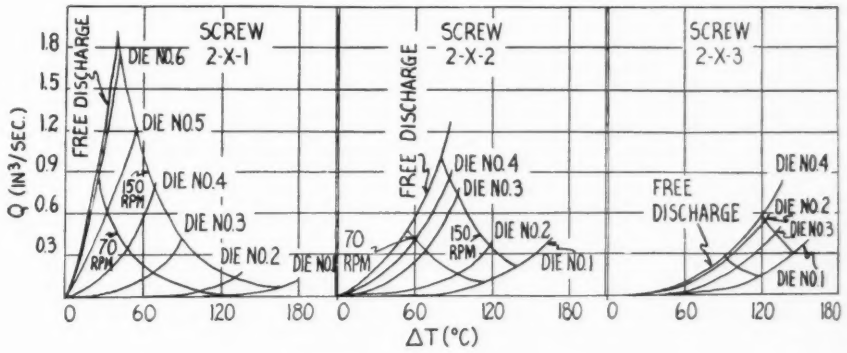


Fig. 6. Calculated Adiabatic Performance Diagrams for Experimental Screws. Q Is Extrusion Rate, and △T Is Temperature Rise of the Molten Plastic

It is convenient to plot the performance data on an extrusion rate *versus* temperature rise diagram, and three diagrams, one for each of the screws, are shown in Figure 5. These diagrams show that the range of extrusion rates and temperatures obtainable with screw 2-X-1 is extremely broad; while the shallower flight screws have much narrower operating ranges.

It is interesting to compare the actual extruder performance with the theoretical adiabatic melt extrusion performance calculated for these screws. The diagrams in Fig. 5 have superimposed on them shaded outlines of the theoretical performances which are also shown in Figure 6. It is immediately noticeable that for screw 2-X-1, the peak extrusion rate is considerably reduced. At 150 rpm. and with die No. 6, the observed extrusion rate is 1.28 in³/sec. compared with the theoretical extrusion rate of 1.75 in³/sec. The observed temperature rise is 12° C., compared with the theoretical rise of 43° C.

We believe that heat conduction through the metal of the barrel is the primary cause of this deviation. The large mass of metal in the extruder barrel offers a path of very low resistance for heat conduction along its length toward the relatively cool hopper section; while for truly adiabatic operation the barrel would have to be a perfect insulator. Consequently, in operation, the temperature profile along the barrel is much flatter than the adiabatic theory predicts. In other words, heat is taken from the front and conducted to the rear by the barrel, and the effective viscosity at the beginning of the metering zone is considerably lowered.

Consider now the high pressure part of the performance diagram. Here the observed extrusion rates are higher than the calculated. The heat conduction effect is, of course, still operating, but we believe that it is overshadowed by another effect. This is the non-Newtonian flow effect. The adiabatic theory was derived on the assumption that the flow behavior was Newtonian. For Newtonian flow through a die, the flow rate, at any given temperature, is directly proportional to the die pressure. In the case of non-Newtonian flow, however, the flow rate through the die is proportional to the pressure raised to some power greater than one. For polyethylene, the exponent is about 2.2. Therefore, for any given temperature and pressure, more of a non-Newtonian material will get through the die than will a Newtonian material. For dies of high flow restriction, where high pressures are generated, this effect becomes important, as the die is not so effective a restriction as the calculations indicate. Consequently, the extrusion flow rates are correspondingly higher.

These same effects are noticeable when the observed and calculated performance of the other two screws is compared, although, since the operating range is much narrower, the magnitude of the deviation is not so great.

Further experiments were carried out with screw 2-X-3 to investigate the effect of increased barrel temperature. One set of runs was made applying voltages in the range of 10-30 to the barrel heaters. A second set of runs was also made using an applied voltage of 85. As the diagram in Figure 5 shows, the higher barrel temperatures caused the extrusion temperature to rise, although it had a small effect on the extrusion rate. The change in performance produced by the different barrel temperatures illustrates how heat transfer can extend the operating ranges of the screws.

The power data for all the runs are also summarized in Table 2, including the input power; the output power; the heat losses from the extruder from all sources except the cooling-water stream; and the percentages of the total power applied to the system by mechanical working. In runs 1-22, the average percentage runs higher than 90. For the last four runs, made with the higher barrel heater temperature, the average is about 70%.

Another index to extruder performance is the so-called power economy, expressed as pounds extruded per horsepower-hour of mechanical energy expended. These figures are listed in the last column of Table 2.

In summarizing the performance characteristics of the three screws, it is interesting to note how drastically the characteristic of the very shallow screw (2-X-3) differs

from the deep one. The range of throughput and temperature conditions which can be covered by the shallow screw without generating excessive pressures is obviously much smaller. It is also evident that the principal advantage of this screw lies in extrusions where very high discharge temperatures are needed.

On the other hand, the shallow screw has the obvious disadvantage that the range of extrusion conditions which can be covered by varying the back pressure is extremely small. All of the extrusion conditions covered by the 0.033-inch-deep screw (2-X-3) can also be reached by the 0.117-inch-deep screw (2-X-1) if we were to operate it a bit faster. The 0.117-inch-deep screw is therefore useful for a wider variety of applications.

An overall look at Figure 6 indicates that considerable advantages might be gained by operating extruders at higher speeds. As screw speed is increased, the slope of the discharge curve for a given die increases. Thus the higher screw speeds will appreciably raise the output of a machine, but will have a diminished effect on stock temperature.

Summary and Conclusions

Our experimental work has demonstrated that polyethylene extrusion under near-adiabatic conditions is indeed obtainable in practice. While the correlation between the observed and calculated performance leaves something to be desired (particularly at the extremes of very high and very low die resistances) the adiabatic melt extrusion theory *can* serve as a semi-quantitative guide to the design of extruders for operation with predominately mechanical power. The experimental work also shows that any combination of a very wide range of extrusion rates and temperatures can be obtained without any transfer of external heat to the plastic, and that the ultimate capacity of the extruder for polyethylene is limited only by the speed and the power that the drive can supply. In addition, high extrusion temperatures can be obtained without the necessity of transferring heat from external sources through a high-temperature gradient.

Can other plastics also be extruded under near-adiabatic conditions, and, if so, will these same advantages be obtained? As we have mentioned before, whether or not a plasticating extruder can be operated adiabatically depends mainly on the solid-state properties of the plastic. For polyethylene, rubber-like materials, and elastomers the answer is clear. For other plastics, experimentation is necessary before the question can be answered.

Assuming that a plastic *has* the desired solid-state properties, will it be possible to obtain adiabatic control over a wide range of extrusion rates and temperatures, or is the performance of polyethylene unique? As we have seen, adiabatic control over broad limits depends to a great extent on the screw design and the operating conditions. The widest range of adiabatic control is possible when the extruder is operated at high speeds. The screw design dictates the area of operation. Good adiabatic control also depends, however, on certain viscous properties of the plastic melt itself. Two properties stand out as being of primary importance:

VISCOSITY: If the plastic has a high melt viscosity, a large amount of heat can be generated through viscous shearing, and a wide range of adiabatic control is possible. Conversely, with materials of very low melt viscosity, it would be difficult, under practical extrusion conditions, to generate much heat mechanically, and heat transfer must be relied upon for temperature control.

VISCOSITY-TEMPERATURE COEFFICIENT: A material whose viscosity is reduced only slightly by increasing temperature has a low viscosity-temperature coefficient, i.e., a low energy of activation for viscous flow. High extrusion temperatures are more easily reached with plastics of this nature than with plastics whose melt viscosity is greatly reduced by small rises of temperature. Material with the latter behavior is unlikely to reach high temperatures in an extruder because the shear stresses and the mechanical working drop with the viscosity.

The extruder size is another factor which should be considered. In large extruders the ratio of the area available for heat transfer to the theoretical extrusion rate becomes small, since the heat transfer area is roughly a function of the square of the screw diameter, while the theoretical pumping capacity is a function of the cube of the screw diameter. Thus, full advantage of large extruders will be obtained only when the operation is carried out with heat that is predominantly mechanically generated. We have referred to theoretical output in this discussion because in actual practice, extruder rates are more in proportion to the square of the diameter, indicating that heat transfer is controlling the process.

The adiabatic extrusion theory is not only useful in design applications for new extruders, but can also be used to analyze the performance of existing extruders. By using the equations to construct performance diagrams for existing screws, the potentialities of each screw will be recognized, and more advantageous operating conditions may be found.

The application of adiabatic principles need not be confined to those extrusion operations where mechanically generated heat dominates. Even in cases where heat transfer governs the melting of the plastic and may limit the capacity of the extruder, mechanically generated heat may augment heat transfer and extend the operating range of the machine.

One final point concerning the application of the theory should be made. Even in those cases where near-adiabatic operation is possible, it is generally advantageous to design screws for adiabatic operating temperatures less than those actually desired and to use transferred heat to bring the stock to precisely the desired temperature. The final fine control of stock temperature can then be obtained through the use of barrel heaters operated through control instruments.

Plans Expanded Teflon Production

An expansion project that is expected to result in about double the present capacity for producing Teflon tetrafluoroethylene resin has been announced by E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Erection of new facilities will be started soon as an addition to the Washington Works near Parkersburg, W. Va., the site on which the company began the first commercial-scale manufacture of the synthetic resin in 1950.

Production of both major forms of Teflon, the powders used in making molded articles and the dispersions employed in the manufacture of electric wire enamels and coated fabrics, will be increased. The decision to expand, du Pont said, reflects a steady growth in sales of the product and the company's confidence in its future growth as new applications for the plastic continue to be found. Among such new applications is the recently announced experimental Teflon fiber that possesses most of the heat and chemical resistance of the resin.

Meetings and Reports

SPE Sections Hold Outings

Golf at Philadelphia

The combined annual golf outing of the Philadelphia Section, SPE, and the Philadelphia Chapter, SPI, was held June 22 at the Huntington Valley Country Club, Abington, Pa. Approximately 130 members and guests attended.

Some 94 golfers competed for prizes in the golf tournament. Winners included: Dan Jones (Owens-Illinois Glass Co.) with a low gross of 77; George H. Koch, Jr. (Oak Engineering), runner-up with a score of 78; Tony Calebro (Calebro Plastics), kickers event; and T. Cox (A. H. Wirz Co.), Calloway system honors.

Many of those attending also toured the F. J. Stokes Machine Co. plant before the outing began.

Cleveland-Akron Outing

The Cleveland-Akron Section, SPE, held a golf and dinner party on June 18, drawing some 50 members and guests for the golfing events and 70 for dinner. In addition to the usual door prizes, winners in the various golf contests also received awards. These included: blind bogey, Wayne Anderson (Anderson & Co.), David Sloane (Lester Engineering Co.), Don Lewis (Packard Electric Co.), Frank Martin (Hoover Co.), and Douglas Eaton (Reed Prentice Corp.); long drive, Paul Zurlinden (Zenith Plastics Co.); and low gross score, Edward Campi (International Molded Plastics).

Metal Stamping Equipment Forms Rigid Vinyl Products

The fabrication of rigid vinyl products on metal stamping machines is now possible by means of a technique developed by B. F. Goodrich Chemical Co., Cleveland, O. First introduced to industry at the recent Plastics Exposition in that city, the method was there applied to the forming of small boxes from Geon vinyl sheeting.

The system is described as using a fast conveyor-belt process to take the sheeting from a preheat oven to the conventional metal stamping press, which forms the finished shape. Rigid sheeting, 1/20-inch thick, feeds from reels under a bank of strip heaters to raise its temperature to 260-275° F. Two sets of driven rubber rollers control the movement of the sheet, and a clutch arrangement permits intermittent feeding to the press. The Exposition installation employed a cycle time of 10 seconds for forming, during which time the stock was cut off from the sheeting. Standard matched molds with a clearance of 0.050-inch between the core and the cavity and with a tolerance of 0.003-inch overall and 0.001-inch on the cutting edge were used.

The company expects that this development will permit metal working companies to enter the plastics fabricating field with little capital outlay since this new system eliminates the need of injection molding machines and hand-operated draw-forming and blow-forming presses for processing rigid vinyl material.

CALENDAR

Sept. 23. Southern Ohio Rubber Group. Fall Technical Meeting.

Sept. 25. Connecticut Rubber Group. Annual Outing. Grassy Hill Park, Sodom Lane, Derby, Conn.

Sept. 30. Fort Wayne Rubber & Plastics Group. Van Orman Hotel, Fort Wayne, Ind.

Oct. 5. The Los Angeles Rubber Group, Inc. Hotel Statler, Los Angeles, Calif.
Buffalo Rubber Group. Westbrook Hotel, Buffalo, N. Y.

Oct. 6-8. Symposium on Applications of Radioactivity in the Rubber and Plastics Industries. Tracerlab, Inc., Boston, Mass.

Oct. 7. Miami Valley Section, SPE.

Oct. 8. Detroit Rubber & Plastics Group, Inc. Detroit Leland Hotel, Detroit, Mich.

Oct. 12-15. National Chemical Exposition. Chicago Section, A. C. S. Chicago, Ill.

Oct. 13. Newark Section, SPE. Military Park Hotel, Newark, N. J.

Oct. 14. Northern California Rubber Group.

Oct. 15. Boston Rubber Group.

Oct. 20. New York Section, SPE. Hotel Gotham, New York, N. Y.
Washington Rubber Group.

Oct. 22. New York Rubber Group. Henry Hudson Hotel, New York, N. Y.

Nov. 3. The Los Angeles Rubber Group, Inc. Hotel Statler, Los Angeles, Calif.

Nov. 10. New York Section and Newark Section, SPE. Joint Meeting. Hotel Gotham, New York, N. Y.

Nov. 11. Northern California Rubber Group.
Miami Valley Section, SPE.

Nov 15-17. ASTM Committee D-20, Plastics. Hotel Carter, Cleveland, O.

Nov. 17. Washington Rubber Group.

Nov. 18. Rhode Island Rubber Club. Metacomet Golf Club, East Providence, R. I.

Dec. 4. Miami Valley Section, SPE. Christmas Party. Hartwell Country Club.

Dec. 8. Buffalo Rubber Group. Christmas Party. Buffalo Trap & Field Club, Williamsville, N. Y.

Dec. 9. Northern California Rubber Group.

Dec. 10. Detroit Rubber & Plastics Group, Inc. Christmas Party. Sheraton Cadillac Hotel, Detroit, Mich.
New York Rubber Group. Christmas Party. Henry Hudson Hotel, New York, N. Y.
Boston Rubber Group. Christmas Party.

Dec. 18. Southern Ohio Rubber Group. Christmas Party.

Extruded Plexiglas Sheeting from R & H

The commercial production of Plexiglas extruded sheet has been announced by Rohm & Haas Co., Philadelphia, Pa. This sheeting is priced below cast sheets, according to the company, and is available in both clear transparent and white translucent forms in thicknesses of 0.060-, 0.080-, 0.100-, and 0.125-inch, widths of 36 and 48 inches, and lengths from 48-96 inches.

Plastics in Housewares and Furniture

Retail sales of plastic housewares last year amounted to more than $130 million, and this year is expected to see an increase in this consumption by some 15%, according to R. C. Evans, director of marketing for Monsanto Chemical Co.'s plastic division. This prospective increase should bring the total weight of styrene, polyethylene, and vinyl plastic which are utilized for these purposes to 80 million pounds.

Of these three plastic materials, styrene has been the most widely used in the past year. Next was polyethylene, and third was vinyl, Mr. Evans stated.

Styrene has even broken into the furniture field. Monsanto has announced that a special formulation of Hi-Test Lustrex plastic, vacuum formed to its desired contour, is being used in a new line of furniture of Heywood-Wakefield Co. Designed by the Industrial School of Design of the Pratt Institute, the experimental models feature simple lines and clear pastel colors.

Monsanto Polyester Application Study Group Formed

A research group to conduct customer service application studies with polyester resins, as well as an exploratory program to develop improved and new processes and products, has been established by Monsanto Chemical Co.'s organic chemicals division at its laboratories in St. Louis, Mo. The new group will be responsible for work formerly conducted by the division's plasticizers investigaton laboratories.

This new group will be under the direction of John F. Palmer, Jr., a Monsanto veteran of 13 years, who has seen service with the company as group leader in charge of research on lubricating oil additives. For the past several months, he has been on a special assignment with the joint Monsanto-National Research Corp. titanium project.

Foaming Vinyl Plastisol Patents Licensed to Bakelite

An experimental licensing agreement under which Bakelite Co., New York, N. Y., will use the patents, held by Elastomer Chemical Corp., Newark, N. J., for foaming vinyl resin plastisols, has been entered into by the two companies. The licensee plans to investigate the qualitative and economic advantages that foamed vinyl products seem to have over foamed rubber products.

Bakelite has announced, in this respect, its willingness to work cooperatively with all other licensees under these patents who are engaged in the commercial application of Bakelite vinyl resins to this field.

For a description of Elastomer's process for producing continuous vinyl foam, see our February, 1954, issue, page 628.

Scientific and Technical Activities

Emphasis on New Synthetic Rubbers for Rubber Division, A. C. S., at New York Meeting in September; Goodyear Medal Lecture to Be Given by Whitby

The program for the sixty-sixth meeting of the Division of Rubber Chemistry of the American Chemical Society, to be held at the Hotel Commodore in New York, N. Y., from September 15 through 17, is a full one. This meeting is to be held with the parent Society, and the Rubber Division members may register at the Commodore beginning Wednesday morning, September 15, or at any of the other hotels where meetings of the Society's other divisions are being held.

The technical sessions will begin Wednesday afternoon, with Division Chairman J. C. Walton, Boston Woven Hose & Rubber Co., presiding, and will continue on Thursday and Friday mornings and afternoons. Most of the papers to be presented on Thursday, September 16, will deal with new synthetic rubbers, including fluorocarbon rubbers, carboxylic elastomers, Butyl-type polymers containing bromine, and sulfur-curable silicone rubbers. Some very interesting new information, as will be seen from the abstracts below, will be revealed at these Thursday sessions. Equally interesting information on a wide range of subjects will be presented at the other sessions.

In addition, the Charles Goodyear Medal Award Lecture will be given on Thursday morning by this year's medalist, G. Stafford Whitby, University of Akron. His subject will be, "Reflections on Rubber Research." The Medal Award ceremonies will take place at the Division banquet on the evening of the same day. Further details regarding Dr. Whitby's selection as the 1954 Goodyear Medalist appeared in our May, 1954, issue on page 71.

At the business meeting, also on Thursday morning, the results of the election of officers and directors of the Division will be announced.

The Division's 25-Year Club will have a luncheon meeting Wednesday, and Bruce Silver, New Jersey Zinc Co., will be in charge of this affair.

The Division banquet on Thursday evening at the Commodore will be preceded by the Suppliers Cooperative Cocktail Party, which is promised to be one of the best ever by E. B. Curtis, R. T. Vanderbilt Co., and J. M. Hamilton, Binney & Smith Co., in charge of this event. Several top-flight acts of entertainment featuring television, radio, and stage personalities will be presented at the Division banquet, to which ladies are invited.

Because of the very full program of technical papers, no plant trips have been arranged by the Division's local committee on arrangements, but plant trips are on the program for all members of the Society. Similarly the Division has not planned any ladies' program of its own, but the Society is providing an interesting and extensive program for the women under the direction of Hazel Bishop.

The local committee on arrangements is headed by Joseph A. Breckley, Titanium Pigments Corp., with George N. Vacca, Bell Telephone Laboratories, as vice chairman. Other members of the local committee follow: A. H. Eufer, Vanderbilt, banquet; A. S. Lang, H. V. Hardman Co., finance; J. Roy Keating, Binney & Smith, information; C. W. Sweitzer, Columbian Carbon Co., program and meeting rooms; and S. M. Martin, Jr., Thiokol Corp., publicity.

Program and Abstracts of Papers

WEDNESDAY MORNING—SEPTEMBER 15

9:00 a.m.—Registration.

11:00 a.m.—25-Year Club. Bruce Silver, Chairman.

WEDNESDAY AFTERNOON—SEPTEMBER 15
J. C. WALTON, *Presiding*

Fabian Bachrach

J. C. Walton

2:00 p.m.—1. Introductory Remarks. J. C. Walton.

2:10 p.m.—2. **Studies on the Determination of Relative Road Wear Ratings of Tire Tread Stocks.** F. H. Amon, E. M. Dannenberg, Godfrey L. Cabot, Inc., Boston, Mass.

During the past decade the production of carbon black by the channel process based on natural gas as the raw material has largely been replaced by furnace processes utilizing aromatic oil raw materials. This major change has resulted in the introduction of many new qualities of oil furnace blacks covering a wide range in particle size and reinforcing properties. In the manufacture of tires these new blacks have found applications in all the important tire components. The marked improvement in the road wearing properties of tire treads in recent years has been due in part to the availability of the more reinforcing grades of oil furnace blacks. In the development of these new carbon blacks and for the careful control of their quality levels the results of controlled road testing programs have played a major role.

Cabot test cars have been operated on a continuous basis since 1948, and today almost 2,000,000 vehicle miles have been completed. Although the primary purpose has been evaluation and control of carbon blacks of many types, these road tests have also resulted in other information of general interest on tire testing variables and techniques. The application of variance analysis to both whole-tire and two-way tire test procedures is demonstrated. For the purpose of establishing the relative wear ratings of tread stocks, it has been found that greater precision is possible with "half and half" or two-way treads than with whole treads. From the standard deviations of the relative ratings observed using both two-way and whole-tire treads, it appears that two-way construction is almost four times more efficient than whole-tire construction. A comparison of relative tire wear ratings by both depth loss and weight loss methods is presented.

Additional information on the influence of speed, atmospheric temperature, type of road, and wheel positions on road wear and the relative road wear performance of various types of carbon blacks in both natural and synthetic rubber is discussed.

2:35 p.m.—3. **Relaxed Compression Set—A Definitive Property of Vulcanizates.** L. R. Sperberg, Sid Richardson Carbon Co., Odessa, Tex.

One of the paramount problems confronting the rubber technologist today is the lack of a suitable means for measuring the fundamental property of state of cure of soft rubber vulcanizates. Many criteria, such as tensile corner, modulus inflection point, free sulfur, etc., are used, but experience has shown they are better measures of rate than of state of cure.

With this problem the author soon concluded that before one could measure, one must of necessity define vulcanization. Many definitions exist, but the simplest is one which defines vulcanization by reference to the most noticeable change which occurs during vulcanization—any treatment which decreases plasticity without lowering elasticity. With vulcanization thus defined, the author reasoned that measurements of set acquiring characteristics of vulcanizates should quantitatively indicate state of cure.

With this background and during the past several years the relaxed compression set test evolved. In its present form it has been used by the author more than seven years.

The relaxed compression set test gives results independent of degree of compression as long as the structural strength of test specimens is not exceeded during compression. This test works for all types of vulcanizates—gum, pigmented, natural, synthetic, sulfur, non-sulfur, etc. The results are expressed numerically between 100 and zero.

The relaxed compression set test can be used to study the mechanism of vulcanization; at normal operating temperatures a measure of intermolecular bonds is obtained; while at subnormal temperatures a measure of intramolecular bonding can be estimated.

When vulcanizates are compared at

equal compression set values, individual influences of any of the compounding ingredients can be readily determined. Many physical properties vary linearly with change in compression set. Temperature coefficients of vulcanization calculated from relaxed compression set data are in agreement with published values.

The relaxed compression set test reports a definitive property of vulcanizates, and to one familiar with the test, a definite value of relaxed compression set is highly indicative of a specific state of cure.

3:00 p.m.—4. **Fatigue of Rubber with Two-Way Stretching.** S. D. Gehman, R. P. Clifford, Goodyear Tire & Rubber Co., Akron 16, O.

Flexing failure of rubber in service is generally due to repeated complex strains. Laboratory flex testing, on the other hand, has usually been based on a relatively simple extension and retraction cycle.

A machine was constructed and used to study the fatigue of rubber subjected to biaxial strains of controlled amplitude and phase relations. Alternate biaxial straining (strains 180 degrees out of phase) was the most severe phase condition and reduced the flex life of a cold rubber tread compound by a factor of 11 in comparison with one-way stretching. In-phase biaxial straining reduced the flex life by a factor of 1.7.

The severity of alternate biaxial straining was attributed to the stretching which occurred transverse to induced fiber structure and to the persistence of fiber structure at the point of zero strain. Alternate biaxial straining was accompanied by high hysteresis losses, as shown by the temperature rise of the surface. This rise was sufficient to affect the flex life so that for this type of deformation there was a definite dependence of flex life on hysteresis. Alternate biaxial straining gave flex life *vs.* cure curves with a plateau or broad maximum for a range of cures. It provided a means for selecting an optimum cure range for this type of flex life for each polymer. In this way polymers could be compared at their optimum cures for flex life.

3:25 p.m.—5. **Smearing of Vulcanized Rubber.** S. D. Gehman, C. S. Wilkinson, Jr., R. D. Daniels, Goodyear.

The surface heating which occurs at the interface of rubber sliding under load may be part of the mechanism of abrasion, especially under severe conditions. Removal of rubber by thermal degradation and a smearing process occurs if the rubber surface attains sufficiently high localized temperatures.

A procedure, using a melting point bar, was developed for measuring the temperature at which smearing occurred for rubber vulcanizates. Smear points reproducible to about ±2° F. were measured. The effect of compounding variables on the smear point was investigated. The most important compounding variable affecting the smear point of natural rubber was the accelerator system. Smear points for conventional types of rubber tread compounds were in the neighborhood of 400° F. The highest smear points, about 470° F., were obtained with Tuads acceleration. GR-S tread compounds had smear points greater than 500° F.

The relatively high smear point of GR-S may be an important factor in explaining its superiority in road wear under severe service conditions. Laboratory abrasion experiments were performed to illustrate the effect of smearing on the relative abrasion loss of GR-S and natural rubber tread compounds.

3:50 p.m.—6. **Milling Procedure: Its Effect on Physical Properties.** B. J. A. Martin, D. Parkinson, Dunlop Rubber Co., Ltd., Birmingham, England.

From general theoretical considerations it is possible to regard the milling of natural rubber, which includes mastication, mixing, and premolding processes, as producing two effects which may be opposed so far as the resulting physical properties are concerned. Thus, for example, molecular weight can be reduced while carbon-rubber or other reinforcing structure is formed. Or, again the formation of one kind of carbon-rubber structure may be accompanied by the breakdown of another. The direction and the magnitude of the resultant effect on physical properties will depend on the milling conditions deliberately or accidentally imposed.

Using a small production-size Banbury mixer, an experimental study was made of the effect on properties of some of the variations in milling encountered in practice. The variables include time and temperature of mastication and mixing, carbon black concentration in the masterbatch, variation in the order of incorporation of different compounding ingredients, and maturing. In addition, experiments have been made under conditions designed to limit the degree of oxidative breakdown during mixing.

The present experiments have been designed with a definite objective; what degree of control is required over mixing to maintain quality at a uniform level? A general conclusion cannot be reached on this point yet, but the results show that many practically important properties are dependent on variations in milling procedure. For example, the level of tear resistance developed depends on mastication and mixing temperature as well as time, and on the concentration of black in the masterbatch. Fatigue resistance is affected by mastication time, and the temperature developed during flexing of the vulcanizate shows dependence on both time and temperature of mastication.

Also, electrical conductivity is strongly dependent on time and temperature of mixing as well as masterbatch black concentration. Properties can be affected also by the stage of the mixing cycle at which compounding materials are added. Thus, with high mixing temperatures, early addition of zinc oxide increases appreciably the scorchiness of the stock.

4:20 p.m.—7. **Correlation of Room Temperature Shelf Aging with Accelerated Aging.** R. A. Youmans, G. C. Maassen, Vanderbilt, New York.

Natural rubber stocks were shelf aged 22 years at room temperature and tested for physical properties at intervals during that period. Similar stocks were aged in individual test tubes at 70° C., in the oxygen bomb at 70° C. and 300 psi., and in the air bomb at 127° C. and 80 psi.

The results of these tests show that none of the accelerated test methods deteriorates all physical properties at the same rate. They may be used to predict tensile and elongation decay over a long period of shelf life, but fall short in predicting modulus changes over the same period. Of the three types of accelerated aging methods used, the 70° C. test-tube method simulates natural aging changes most closely.

4:40 p.m.—8. **The History of the Rubber Latex Industry.** Ernst A. Hauser, Massachusetts Institute of Technology, Cambridge, Mass.

The first patent for impregnating fabrics with latex was issued to Thomas Hancock in 1830. In 1850, Adriani reported that the dry rubber content of latex varied with the place on the tree from which it was obtained. Fourcroy had already pointed out in 1791 that latex could be preserved by the addition of alkali, but it was not until 1853 that a patent for the preservation of latex with ammonia was granted to Johnson. In 1855, Newton obtained a patent for the use of certain fillers with latex to act as binders for colors. The first patents covering the manufacture of molded articles directly from *Hevea* latex were issued to Hancock and Silver in 1864.

The first book devoted to rubber latex and its direct utilization in industry was written by Dr. Lucien Morisse, published in French in 1908. The first really scientific contributions on rubber latex were made by E. A. Hauser after his return from the Malay Peninsula in 1924 and again in 1927. He also wrote a monograph about latex based on colloid-chemical studies. This book was published in Germany in 1927 and, after translation by W. J. Kelly, in the United States in 1930. In 1928, Hauser's Gow Lectures on the colloid chemistry of the rubber industry were published, and in the following year Paul Stamberger gave another series of lectures in London which appeared in print in 1929. These contributions must be classified as the actual foundation of the rubber latex industry.

Since then several books have been published relating to the use of rubber latex in industry. Reference will be made to the contributions of Royce J. Noble, H. P. Stevens, P. H. Schidrowitz, A. Block and G. Genin, C. F. Flint, J. le Bras, etc.

THURSDAY MORNING—SEPTEMBER 16
J. C. WALTON, *Presiding*

9:00 a.m.—9. **"Kel-F"[1] Elastomer: A New Fluorocarbon Rubber.** M. E. Conroy, L. E. Robb, D. R. Wolf, F. J. Honn, M. W. Kellogg Co., Jersey City, N. J.

This new elastomer, a copolymer of chlorotrifluoroethylene containing more than 50% fluorine, is being made in experimental quantities by M. W. Kellogg for preliminary evaluation. A large pilot plant, scheduled for completion early in 1955, will provide material for more extensive field test.

"Kel-F" Elastomer is available as a white spongy crumb (specific gravity, 1.85) or as a water dispersion. Because of its completely saturated chain structure, "Kel-F" Elastomer cannot be vulcanized by ordinary methods. However, polyisocyanates, polyamines, and organic peroxides in conjunction with basic metal oxides will cross-link the gum to form strong, elastic unfilled vulcanizates with tensile strengths up to 2,500 psi. and elongations of 400-600%. Certain silicas provide additional reinforcement and tensile strengths up to 3800 psi.

"Kel-F" Elastomer is outstanding for its resistance to heat, solvents, chemicals, ozone, weathering. It is especially noteworthy for its resistance to fuming nitric acid and other oxidants.

This paper will describe a number of recipes for vulcanizing "Kel-F" Elastomer, with emphasis on the physical and chemical properties of several peroxide cured stocks.

9:25 a.m.—10. **Compounding Studies of Copolymers of Chlorotrifluoroethylene.** C. B. Griffis, J. C. Montermoso, Quartemaster Research and Development Center, U. S. Army, Natick, Mass.

[1]Registered trade mark of M. W. Kellogg Co. for its fluorocarbon polymers.

A new type of fluorocarbon rubbers developed by the Kellogg company in cooperation with the Office of the Quartermaster General, U. S. Army, has been made in sufficient quantity for compounding studies. The rubber reported here is a copolymer of chlorotrifluoroethylene. As this material exhibits rubbery rather than plastic properties, vulcanization is necessary to obtain useful products. Having no unsaturation along the polymer chain, it is not readily vulcanized by normal rubber curatives. This rubber has been successfully vulcanized with benzoyl peroxide, polyamines, diisocyanates, diisothiocyanates, and diisocyanate-amines.

Reinforcement filler studies established a silicone treated silica pigment as an unusual reinforcement filler. A softener study indicates that a wide variety of materials could be added to this fluorocarbon rubber to improve processing. The compounded vulcanizates have outstanding chemical resistance to strong oxidizing acids and petroleum-base fuels. The vulcanizates have excellent aging and weathering characteristics, flame resistance, and thermal stability.

9:45 a.m.—11. **"Kel-F"[1] Elastomer Fabrication and Applications.** L. E. Robb, D. R. Wolf, M. E. Conroy, F. J. Honn.

The fabrication of rubber goods from compounded "Kel-F" Elastomer can be carried out with standard rubber equipment. The compression molding of mechanical goods such as O-rings and diaphragms is discussed. Little difficulty is experienced in the incorporation of reinforcing fabrics in molded goods.

The extrusion of compounded stocks, as performed on standard rubber extruders, is discussed. Items fabricated by extrusion must generally be cured under slight pressure to preclude "blowing" of the peroxide curing agents. The calendering of "Kel-F" Elastomer to produce thin, tough sheet stock is discussed.

The solubility of "Kel-F" Elastomer in ketones and esters is described. This solubility makes the rubber ideal for the formulation of chemical and heat resistant coatings and coated fabrics.

The results of performance tests on several items fabricated from "Kel-F" Elastomer are presented.

10:10 a.m.—12. **Fluorocarbon Rubber Research.** F. J. Honn, J. M. Hoyt, and A. N. Bolstad, Kellogg; C. B. Griffis, J. C. Montermoso, Quartermaster Corps, U. S. Army, Natick.

To promote the development of a rubber which is both oil-resistant and flexible at low temperatures, the Quartermaster Corps has sponsored an "Arctic Rubber" program at M. W. Kellogg since 1950 on the synthesis of fluorocarbon elastomers. Fluorocarbons were selected for study because the two best-known fluorine polymers, "Kel-F"[1] and Teflon,[2] are chemically resistant to a high degree and serviceable over a wide range of sub- and super-normal temperatures. Data are presented here on a few of the many elastomers prepared to date from a variety of fluorinated monomers, many of which are newly synthesized.

10:35 a.m.—13. **Poly-FBA: A Fluorine-Containing Polyacrylic Rubber.** P. J. Stedry, J. F. Abere, Minnesota Mining & Mfg. Co., St. Paul, Minn.

Solvent-resistant and heat-stable polyacrylic rubbers with fluorinated side-chains were developed by Minnesota Mining under a contract with Wright Air Development Center, U. S. Air Force. The homopolymer of 1,1-dihydroperfluorobutyl acrylate, better known as Poly-FBA, is the first of these to reach pilot-plant production.

The monomer is derived from perfluorobutyric and acrylic acids and polymerizes readily in a simple emulsion recipe to form a stable latex. Dry Poly-FBA can be processed on conventional rubber equipment and formed into molded or extruded shapes. Vulcanization is best accomplished with polyfunctional amines, and the compounds can be reinforced with carbon blacks or inorganic pigments. Basic compounding technology will be presented.

Typical Poly-FBA vulcanizates have tensile strengths ranging from 1,200 to 1,500 psi. and compression sets of 20 to 25%. Modulus, ultimate elongation, and hardness can be readily adjusted. The compounds exhibit very low swelling in aliphatic and aromatic hydrocarbons, alcohols, chlorinated solvents, water, and acids. These compounds are also suitable for extensive service in oils, synthetic lubricants, hydraulic fluids, and similar high-boiling liquids at temperatures up to 400° F. In addition, Poly-FBA is inert to ozone and resistant to fuming nitric acid. Its principal shortcoming lies in limited low-temperature flexibility.

This combination of properties, hitherto unknown in an elastomeric material, indicates uses for Poly-FBA as a specialty rubber under conditions of severe heat and oil exposure. First applications are expected to develop in the field of O-rings, gaskets, packings, valves, diaphragms, lubricant and hydraulic hose, roll coverings, and similar products.

11:05 a.m.—Business Meeting.

11:20 a.m.—Charles Goodyear Lecture: **Reflections on Rubber Research.** G. Stafford Whitby.

THURSDAY AFTERNOON—SEPTEMBER 16
C. R. HAYNES, *Presiding*

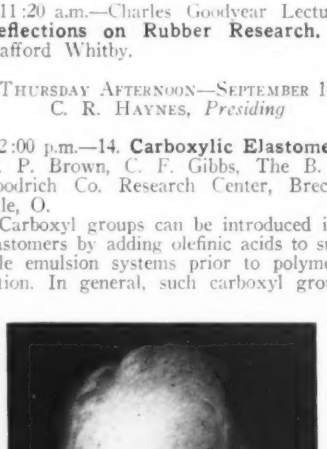
2:00 p.m.—14. **Carboxylic Elastomers.** H. P. Brown, C. F. Gibbs, The B. F. Goodrich Co. Research Center, Brecksville, O.

Carboxyl groups can be introduced into elastomers by adding olefinic acids to suitable emulsion systems prior to polymerization. In general, such carboxyl groups elevate the elasticity temperature range, impart superior filming properties, increase resistance to swelling by hydrocarbon solvents, and render the polymers susceptible to cross-linkage, gelation and vulcanization by polyvalent reagents.

In vulcanization recipes based on sulfur, but containing polyvalent metal salts, the presence of as little as 1% of a carboxylic monomer is recognizable through its influence upon vulcanizate properties.

Carboxylic elastomers can be cross-linked by reactions of the carboxyl groups. Salt formation with zinc oxide without pigmentation gives stocks having stress-strain properties equaling or surpassing those of black pigmented sulfur cured vulcanizates of analogous non-carboxylic polymers. Several divalent metal oxides and other salts can be used as vulcanizing agents. The metal oxide vulcanizates possess excellent stress-strain properties, but poor compression sets. Certain vulcanizates are improved by the inclusion of small amounts of organic acids. An excess of organic acid will cause devulcanization. Blacks function principally as loading rather than reinforcing pigments.

The properties of vulcanizates of carboxylic elastomers of the butadiene, butadiene with acrylonitrile, butadiene with styrene, and ethylacrylate copolymer systems are described.



Conway Studios

C. R. Haynes

2:25 p.m.—15. **Butyl-Type Polymers Containing Bromine.** R. T. Morrissey, Goodrich Research Center.

Butyl-type polymers have been modified by introducing about 1.0 to 3.5% bromine on to the polymer chain. The polymers may be prepared by adding bromine to a solution of the Butyl-type polymer. The reaction has been considered as mainly one of addition to the double bonds, thereby lowering the unsaturation of the Butyl. Accelerator and sulfur requirements are consequently decreased, while the cure rate of the polymer, as compared to Butyl, is greatly increased. Both sulfur and metal oxide-type cures are applicable to these bromine-containing polymers. Unlike Butyl rubber, the modified Butyl can be covulcanized with natural rubber and GR-S, and thus it is now possible to impart the excellent properties of Butyl such as ozone resistance, low air diffusion, and flex cracking resistance to these rubbers, while still maintaining good stress-strain properties. Still other advantages, as compared to Butyl rubber, are higher modulus and good adhesion to other elastomers and metals.

Data are presented to show that the properties of these new Butyl-type polymers can be varied by the amount of bromine which they contain. It is also shown that an optimum amount of the halogen is required for the best properties, both in mixtures with natural rubber and as an adhesive. This optimum amount of bromine also depends upon the original unsaturation of the polymer.

The new Butyl-type polymer is being made available to industry by the B. F. Goodrich Chemical Co. under the commercial name, Hycar HH.

2:50 p.m.—16. **Sulfur-Curable Silicone Rubber Compositions and Blends with Hydrocarbon Elastomers.** Dallas T. Hurd, Robert C. Osthoff, General Electric Research Laboratory, Schenectady, N. Y.

Silicone rubber gum stocks containing small percentages of silicon-bonded vinyl groups can be prepared by the copolymerization of polydimethylsiloxanes with polymethylvinylsiloxanes. These gums can be compounded with carbon black fillers and cured with conventional sulfur vulcanizing agents.

[2] E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Vinyl-containing silicone gum stocks can also be compounded in various proportions and covulcanized with hydrocarbon-chain elastomers such as natural rubber, GR-S, Butyl, or Perbunan. Since no "bleeding" occurs on long standing, the covulcanizates appear to be permanent. The measured properties of the blends are intermediate between those of the separate components. Certain of the butyl-silicone covulcanizates appear to have superior electrical properties and an unusual degree of flexibility at temperatures as low as —50° C.

It is anticipated that investigation of the preparation and properties of vinyl-siloxane-hydrocarbon covulcanizates may yield information of value in determining the mechanism of the sulfur vulcanization of rubbers.

3:15 p.m.—17. **Morphological Studies of Elastic Silicones.** Ernst A. Hauser.

This is the first report on the morphology of elastic silicones. This investigation deals with methyl-silicones only. They differ in their morphology from any synthetic elastic polymer investigated so far with the exception of Butyl rubber, which exhibits some similarity to the morphology of elastic silicones. Depending on the molecular weight distribution of the investigated elastic silicone, one finds the formation of broad bands, very fine threads, and some interspersed with very small globules.

On the basis of already existing knowledge the conclusion may now be drawn that only such natural or synthetic elastic polymers will show the formation of very fine threads which permit the alinement of their molecules without too great difficulty.

Elastic silicones also show a similarity to the non-vulcanizable polyisobutylene. This becomes more and more noticeable as more of the lower molecular weight compound is used for the preparation of the silicone sample. It is therefore most probable that the methyl groups located at the surface of natural rubber, Butyl rubber, polyisobutylene, and methyl-silicones are mainly responsible for the formation of very fine threads which occasionally are interspersed with small globules.

Photo-ultramicrographic demonstrations will be offered during the presentation of the paper.

3:40 p.m.—18. **Fibrous Rubber, Its Production and Properties.** Worth Wade, Laurence R. B. Hervey, Derek E. Till, Ralph M. Winters, Jr., American Viscose Corp., New York.

A new physical form of rubber called fibrous rubber consists of a web formed of a multiplicity of small rubber fibers in random distribution and bonded together at their points of crossing. The web is formed by a modified spray process called fibrillation and can be produced from natural or synthetic rubber, which is compounded with the customary vulcanizing and curing agents.

The fibers may be solid or hollow. The web is characterized by high porosity, high tensile strength, low density and high tear resistance, as compared to foam, sponge, and sheet rubber. Data are given for the elastic modulus, average diameters, tensile strength, and elongation of the individual rubber fibers and of the web.

Suggested uses are: cushion innersoles for shoes, pads for carpets, porous elastic wearing apparel, elastic bandages, and rainwear which is water repellent, but capable of passing water vapor.

4:05 p.m.—19. **Amine Activators for Emulsion Copolymerization of Butadiene and Acrylonitrile.** J. W. L. Fordham, H. Leverne Williams, Polymer Corp., Ltd., Sarnia, Ont., Canada.

J. Ball

The copolymerization of butadiene and acrylonitrile at 30° C. in emulsion using potassium persulfate as initiator is strongly activated by certain cyanoethylated amines, particularly dimethyl aminopropionitrile. As the temperature of polymerization is reduced, other cyanoethylated amines which are more reactive are required.

In particular the cyanoethylated ethanolamines are useful. If the cyanoethylated amine by itself is not a suitable activator, the addition of a trace of ferrous iron may enhance its effectiveness greatly. The cyanoethylated amines can also be used when organic hydroperoxides, such as cumene hydroperoxide, are used as polymerization initiators, especially if dextrose is included as a coreducer. The latter system may also be used for the emulsion copolymerization of butadiene and styrene; whereas the former is very inefficient when butadiene and styrene are the sole monomers. One of the roles of glucose would appear to be the formation of glucoylamines resistant to cyanoethylation.

The type of emulsifier used in the polymerization recipe markedly alters the shape of the time conversion curve. When long-chain alkyl sulfonate or alkyl carboxylic acids are used, the time conversion curve is linear. When other synthetic emulsifiers are used, the time conversion curve is S-shaped; the reaction rate increases during the first several hours.

4:30 p.m.—20. **Butadiene/Styrene Copolymers—100% Conversion of Monomers.**[3] T. W. Boyer, N. R. Legge, Kentucky Synthetic Rubber Corp., Louisville, Ky.

The removal of unreacted monomers from commercial butadiene/styrene polymerizations and the subsequent purification of the unreacted monomers are costly processes. Prior work to eliminate these processes by reacting to essentially 100% conversion of monomers showed depreciation of copolymer quality as the conversion increased. A reexamination of this problem is reported here.

In 41° F. emulsion copolymerizations of butadiene and styrene using iron pyrophosphate or sodium formaldehyde sulfoxylate activation systems with *para*-menthane hydroperoxide as initiator, the rate of reaction decreased significantly above 70% conversion. Additions of initiator or activator could not prevent this decrease in rate although the decrease was delayed somewhat. With the optimal reaction rates observed at 41° F., the decrease in rate at high conversions was sufficient to penalize overall productivity of the quantitative conversion process by 30 to 40%—in comparison with the 60% conversion process. Gel-free copolymers produced at 100% conversion in the 41° F. system showed lower tensile and elongation than standard cold GR-S (41° F., 60% conversion), but were superior to standard hot GR-S (122° F., 72% conversion). Reaction rates were maintained by increasing the reaction temperature at high conversions.

Initial addition of modifier in this system produced a 100% conversion copolymer with tensile properties equal or inferior to standard 122° F. GR-S. Incremental addition of *tertiary*-dodecyl mercaptan (Sulfole[4]) in the system resulted in a 100% conversion copolymer with tensile properties inferior to LTP GR-S, but better than those of 122° F. GR-S. Incremental addition of modifier provides a better molecular weight distribution, i.e., less low molecular weight polymer than that found in systems containing large initial charges of modifier.

An 85% conversion copolymer produced in this manner was equivalent in tensile to LTP GR-S. In several experiments with this system the bound styrene content of the copolymer was maintained essentially constant throughout the entire range of conversion (0-100%) by additions of butadiene. These 100% conversion polymers showed no improvement in physical properties. Again a marked deterioration of tensile was noted above 85-90% conversion.

The authors conclude that 100% conversion copolymers which are better than 122° F. GR-S, but inferior to LTP GR-S, can be prepared in this 100% conversion system. These polymers would eliminate the costly stripping and monomer purification processes. The depreciated properties of high conversion (70-85%) polymers reported previously in the literature are believed owing to the effects of molecular weight distribution rather than high conversion *per se*.

5:00 p.m.—Suppliers cocktail party.

7:00 p.m.—Division banquet. Charles Goodyear Medal Award.

FRIDAY MORNING—SEPTEMBER 17
J. BALL, *Presiding*

9:00 a.m.—21. **The Analytical Determination of Some Elastomeric Components in Aqueous Extracts.** K. Marcali, du Pont.

The use of elastomers such as neoprene, GR-S, natural rubber, and butadiene acrylonitrile polymers in the manufacture of specialty papers has become of increasing importance in recent years. Since, generally, the addition of an appropriate elastomer appreciably increases the tensile, burst, fold, and tear strength of paper, diversified applications have been found for these papers for many essential services such as food wrappers.

This application requires reliable information on the extractability of elastomer components into various types of solvents, particularly for trace amounts of those components used in the manufacture of synthetic elastomers.

[3] This work was sponsored by the Reconstruction Finance Corp., Office of Synthetic Rubber, as part of a program of research on synthetic rubber.
[4] Phillips Chemical Co., Akron, O.

This paper will discuss sensitive, accurate analytical methods for the determination of zinc, phenothiazine, p-tertiary butylcatechol, a disproportionated rosin, and the sodium salts of 1,1′-methylene-di-2-naphthalene sulfonic acid and 2-anthraquinone sulfonic acid. The chemistry, principle, technique, and general application will be presented.

9:20 a.m.—22. **Identification of Curing Agents in Rubber Products—Ultra-Violet Absorptiometric Analysis of Selective Solvent Extracts.** K. E. Kress, F. G. Stevens, Firestone Tire & Rubber Co., Akron.

A new method has been devised to identify organic compounds which accelerate or retard the vulcanization of commercial rubber products. The organic curing agents are normally acidic or alkaline and can be selectively extracted from a complex compounded commercial rubber stock with dilute aqueous alkali or acid solutions.

Identification is made by obtaining characteristic ultra-violet absorptiometric curves over the 220mμ to 380mμ region on the aqueous alkali or acid solutions, or on liquid-liquid ethyl ether extracts of the aqueous solutions. When extracted curing agents do not exhibit characteristic absorbance maximum, formation of a related compound by simple chemical treatment has made this method applicable to identification of nearly all common organic accelerators used in rubber products today.

The method has been applied to identification of thiazole, thiuram, thiocarbamate, amine, and guanidine classes of commercial accelerators (and some cure retarders) in cured and uncured rubber products. Interference of common softeners and antioxidants is usually negligible.

The procedure outlined is simple and more rapid than isolation by chromatographic procedure. It is much more sensitive and specific than chromatography of colored products or spot tests of chromatographic fractions.

Identification of common accelerators in a rubber stock is regularly made with a two-gram sample in less than four hours.

9:40 a.m.—23. **The Identification of Accelerators and Antioxidants in Vulcanized Rubber Products.** M. J. Brock, George D. Louth, Firestone.

A new approach to the identification of the accelerators used in vulcanized rubber products is described. The procedure includes the separation and identification of amine-type antioxidants.

The problem of accelerator decomposition or transformation during mixing, vulcanization, and extraction has been simplified by an extraction technique which promotes accelerator decomposition. It is shown that most accelerators are composed of one or more of the following constituents: (1) 2-mercaptobenzothiazole (or other thiazole), (2) a guanidine, (3) CS_2, or (4) an amine. These accelerator fragments are collected, separated, and identified. The detection of a thiazole, a guanidine, or CS_2 immediately classifies the accelerator as to type; namely, (1) a thiazole, (2) a guanidine, or (3) a thiuramsulfide or dithiocarbamate. The specific amine identified, if any, designates the particular amine activator, sulfenamide, thiuramsulfide, or dithiocarbamate used. Thus the accelerator used can be determined by the accelerator fragments or combination of fragments identified.

It should be emphasized that no more than four routine identifications are required to identify or classify not only the 24 accelerators included in this study, but any others which may be composed of the same general constituents.

In the method proposed the amine portion of the accelerator is separated by aqueous distillation. It is identified by an X-ray diffraction method previously described.[5] The guanidine accelerators are separated in the basic fraction of the liquid-liquid extraction procedure and identified by their X-ray diffraction diagrams.

2-mercaptobenzothiazole and other acidic thiazoles or related compounds occur in the acid fraction, and the amine antioxidants are found in the neutral fraction. These components are identified by their ultra-violet absorption characteristics. Carbon disulfide is isolated and identified as the copper xanthate.

The method has been applied successfully to both vulcanized and unvulcanized rubber products. It is equally useful in the analysis of compounded latex, latex products, and rubber cements. Twenty-four different accelerators and 12 different antioxidants have been studied. Advantages and limitations of the method are discussed.

10:05 a.m.—24. **The Stoichiometry and Fate of Oxidation Inhibitors in Benzene and Chlorobenzene.** Charles E. Boozer, George S. Hammond, Chester E. Hamilton, Jyotirindra N. Sen, Iowa State College, Ames, Iowa.

The chemistry of the changes which take place in an antioxidant in its role of protecting an elastomer from oxidation has been the basis of extended research. Such work is most advantageously carried out in model-type compounds rather than in the elastomer itself.

The inhibiting effects of 17 phenols and amines on the auto-oxidation of cumene catalyzed by azo-bis-isobutyronitrile have been studied. All of the inhibitors studied gave reasonably well-defined inhibition periods which were proportional to the inhibitor concentration and inversely proportional to the initiator concentration at any given temperature. The stoichiometry of the inhibition reactions were determined by isolating the products from two of the inhibitors and comparing these inhibitors with the others. Consistent and reasonable stoichiometric factors were determined for most of the inhibitors.

10:30 a.m.—25. **Determination of Latex Particle Size by Adsorption of Electrolytes.** S. R. Ogilby, Goodyear.

Several synthetic and natural rubber latices were carefully measured by conventional electron microscope techniques, and their average particle size was calculated as Volume Surface Average Diameter (DV_s).

These latices were titrated conductometrically with electrolytes at pH levels low enough to inactivate their soap stabilizers. Their stabilities were maintained by the addition of a non-ionic stabilizer.

The titration values were resolved to latex particle size by the use of the Gibbs' adsorption theory. This theory assumes equal surface coverage per molecule adsorbed, thus making it unnecessary to explain the results obtained in terms of either deformed molecules or condensed mono layers at the water hydrocarbon interface. It also accounts for the results obtained with varying molecular sized adsorbents.

Several calculations from these titrations indicate that some of the prevailing theories regarding the surface area covered by soaps should be reconsidered.

[5] M. J. Brock, Marjorie J. Hannum. Paper presented before Division of Analytical Chemistry, A. C. S., Chicago, Ill., Sept. 9, 1953.

[6] Federal Facilities Corp., United States Treasury Department, since July 1, 1954.

11:00 a.m.—26. **Dry Compounding *vs.* Latex Masterbatching of Oil-Extended GR-S.** F. S. Rostler, R. M. White, Golden Bear Oil Co., Oildale, Calif.

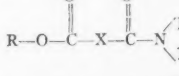
Experience with oil-extended GR-S, as recorded in the literature and revealed in discussions with workers in the field, is in many cases quite contradictory. The investigation reported in this paper traces the cause for this discrepancy in findings to the assumption made by most investigators that the properties of oil-extended polymers of the same composition are independent of the method of incorporation of the oils. The data presented in this paper show that this assumption was erroneous, and that the method of incorporating the extenders has a considerable bearing on the properties of oil-extended polymers.

Parallel series of oil-extended compounds were tested: one series in which extenders of different composition were added in the latex stage, and one in which the same extenders were added by dry mixing. Oils of widely different composition were used in order to accentuate the influence of the type of extender.

Effect of method of incorporation of the extender was primarily on the uncured stock. Oils containing high amounts of N-bases are shown to be suitable extenders for dry compounding, giving good properties, cured and uncured, while the same concentration of N-bases is detrimental in extenders used in latex masterbatching. Low Mooney viscosity values and poor storage stability are characteristic for these latex cocoagulates. It is noteworthy on the other hand that such low Mooney cocoagulates have high physical properties in the cured state. This behavior of extenders is of particular interest since the current Office of Synthetic Rubber, Reconstruction Finance Corp.,[6] specifications permit extenders with the percentage of N-bases found to be detrimental to be used for latex masterbatching.

11:20 a.m.—27. **Alkyl Amates as Elastomer Plasticizers.** Arthur William Campbell, Commercial Solvents Corp., Terre Haute, Ind.

The amic acids comprise a large group of compounds that have not been investigated heretofore as elastomer plasticizers. The work reported here describes the exploratory work both on methods of preparation and application. The alkyl esters of dialkyl amic acids have the following as a representative formula:



where X is zero or any convenient number of methylene groups.

The amates were tried and found to be effective as plasticizers in natural rubber, GR-S, butadiene acrylonitrile, and polyvinyl chloride polymers.

Three methods of preparation will be described, and the tests on approximately 20 new compounds reported.

11:40 a.m.—28. **A Bis-Alkylation Theory of Neoprene Vulcanization.** Peter Kovacic, du Pont.

About 1.5% of the chlorine in neoprene is in a labile form removable by piperidine through a substitution mechanism resulting in a nitrogen-containing polymer. The polymer freed of active chlorine is not vulcanized by many of the common neoprene vulcanizing agents, such as ethylene thiourea, the di-*o*-tolyl-guanidine salt of dicatechol borate and *p,p′*-diaminodiphenylmethane. Vulcanization of the treated neo-

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prene can be effected by sulfur, *p*-dinitrosobenzene, 4,4'-methylene di (phenylisocyanate) or labile dihalides, e.g., 1,4-dichloro-2-butene.

Correlations are made between the nature of the cross-linking agent and the functional groups present in the polymers. It is proposed that vulcanization of neoprene with certain reagents occurs through bis-alkylation of the cross-linking agent, e.g., *p,p'*-diaminodiphenyl methane, by polymer chains at the active chlorine positions. Catalysis of the cross-linking reactions is discussed.

FRIDAY AFTERNOON—SEPTEMBER 17
J. BRECKLEY, *Presiding*

2:00 p.m.—29. **Inhibition of Rubber Oxidation by Carbon Black.** C. W. Sweitzer, K. A. Burgess, Columbian Carbon Co., New York.

In previous publications from these laboratories it has been shown that the presence of small amounts of carbon black in cold rubber represses the gelation of the polymer during prolonged hot Banbury mixing. This repression has been attributed to inhibition by the carbon black of the oxidative reactions which produce gelation. In the present paper the results of further investigations on this inhibition property of carbon blacks are disclosed, involving both gelation and scission reactions in a series of polymers, with particular emphasis on the physical properties of the compounded stocks.

Prolonged cool Banbury mastication of LTP GR-S results in lower Mooney viscosities due to excessive scission of the polymer chains. Stocks compounded from this rubber give lower tensiles. The addition of small percentages of carbon black during the mastication stage was found to minimize this drop in Mooney viscosity and tensile.

Similarly, prolonged hot Banbury mastication of LTP GR-S develops higher Mooney viscosities due to pronounced cross-linking or gelation in addition to the scission reaction. Stocks compounded from this rubber develop modulus levels well above those of normally mixed stocks. The presence of small dosages of carbon black during the mastication stage has been observed to suppress these increases in Mooney viscosity and modulus. It is evident that this effect of carbon black in inhibiting rubber oxidation reactions during prolonged mastication has a profound influence on the properties of the final vulcanizates.

The results of similar investigations with other polymers are also described; these polymers include natural, Butyl, and oil-extended LTP GR-S. The oxidation inhibition property of carbon black is also compared to that of standard chemical antioxidants.

2:25 p.m.—30. **Rubber-Filler Interactions—Solution Adsorption Studies.** E. R. Gilliland, Edgar B. Gutoff, MIT.

The equilibrium adsorption of several polyisobutylenes and Butyl rubber from dilute benzene solutions on different fillers was studied. On Hi-Sil[7] no adsorption was detectable; while on a medium processing channel black slight adsorption occurred. The elastomers were appreciably adsorbed, however, by a high abrasion furnace black.

The adsorption per unit weight HAF black decreased with temperature and increased with the molecular weight of the polymer. The high molecular weight polymers were very preferentially adsorbed, to the extent that molecular weight distribution curves of the elastomers could be constructed. With the lower molecular weight polymers, increasing the solution concentration increased the adsorption, but, in the range 0.25-1%, concentration had no effect on the adsorption of the higher molecular weight materials. In all cases the GR-I-25 (Butyl) behaved according to its molecular weight, indicating no effect of unsaturation. Extracting the black-polymer samples with benzene in Soxhlet extractors removed some, but not all of the adsorbed polymer from the black.

Milling caused the GR-I-25, and to a lesser extent the polyisobutylene, to be highly adsorbed on the MPC black, but did not affect adsorption on the HAF black.

It is felt that the adsorption of polyisobutylene and Butyl rubber by the HAF black is essentially physical, but of a very strong nature, and that this physical adsorption may play an important role in reinforcement. The oxygenated channel blacks seem to adsorb physically very little material, but, under milling conditions, react chemically with the unsaturated groups of the polymer.

J. Breckley

2:50 p.m.—31. **The Surface Treatment of Hydrated Silica Pigments for the Reinforcement of Rubber Stocks.** R. S. Stearns, B. L. Johnson, Firestone.

The effect of particle size, surface area, particle shape, and particle dispersion on the reinforcing ability of finely divided solids in cross-linked elastomers has been extensively investigated. The chemical properties of a surface and its effect on the reinforcing ability of a filler are of primary importance. The introduction of organic groups on to the silica surface through reaction with silanes provides an excellent means of altering the chemical properties of a solid surface. In this manner a series of reinforcing materials of constant area, but of differing reactivity may be produced.

Through the evaluation of the work of retraction of a series of stocks containing various surface treated silicas, it is demonstrated that modulus reinforcement is dependent on the immobilization of polymer chains at the polymer filler interface. This immobilization is the result of free radical-type reactions taking place during high temperature mixing and vulcanization. It is shown that the reinforcing ability of a finely divided solid is dependent on the number of sites on the solid surface and their reactivity.

[7] Columbia-Southern Chemical Corp., Pittsburgh, Pa.

[8] India RUBBER WORLD, Oct., 1952, p. 90 (abstract only).

3:15 p.m.—32. **The Geometric Construction of Copolymer Solvent Phase Diagrams.** F. W. Boggs, United States Rubber Co., New York.

The resistance of elastomers to the action of various solvents is a matter of increasing importance in rubber technology. Because of this, simple methods of summarizing the action of solvents on copolymers should be useful.

The general properties of the triangular-phase diagram of copolymer solvent systems were discussed in a previous paper.[8] Here the qualitative aspects of these diagrams will be related to the partial molar heat of solution of the copolymer. Further it will be shown that the phase diagram can be calculated if the heat of solution of the polymer is known for all compositions.

Since this fact has been established, it becomes possible to construct the phase diagrams geometrically. This procedure is particularly simple if we use interaction parameters of the type which have previously been found applicable to liquid and polymer systems. The values of the solubility parameters can then be related to the type of phase diagram, and this practice permits rapid visualization of the solubility properties of copolymers and makes it possible to construct phase diagrams for a wide variety of systems from a very small amount of initial data.

It is hoped that this will help expedite the evaluation of solvent resistant rubbers.

3:40 p.m.—33. **Polymer Networks Formed in the Presence of Diluent.** R. M. Pierson, A. J. Costanza, F. J. Naples, Goodyear.

Intra-molecular cross-links are known to form when polymers are cross-linked in the presence of inert diluents. The present study was undertaken to determine the extent of the intra-molecular cross-linking as a function of the type and amount of diluent and to find whether elastomer networks which contain an appreciable proportion of intra-molecular links have resilience properties (after removal of diluent) significantly different from networks formed in the absence of diluent.

Flory's quantitative cross-linking agent, decamethylene bis-methyl-azodicarboxylate, was first used with both rubbery (high diene content) and resinous (high styrene content) polymers in the presence of diluents such as benzene in order to prepare networks whose swelling volumes could be used as rough criteria of the relative amounts of inter-molecular ("effective") and intra-molecular ("ineffective") cross-links. When the results were expressed in terms of the ratio of the "apparent Mc" (molecular weight between cross-links formed in the presence of diluent) to the Mc obtained in the absence of diluent, values of this ratio in excess of 4 were found at diluent polymer levels as low as 1:1.

Sulfur-cured gum stocks of high molecular weight Alfin and emulsion butadiene type of elastomers were then prepared in the presence of 25-200 parts of a conventional extender oil, and their resilience properties determined both before and after extraction of oil. Resilience values of the extracted stocks (which contained intra-molecular links in proportion to the amount of oil originally present) were appreciably higher than were those obtained on a series of stocks cured to a range of cross-link densities in the absence of oil, when comparisons were made at equal swell volumes.

Thus the presence of intra-molecular links in tire stocks of oil-extended rubbers appears to be an important factor in accounting for their excellent service performance.

4:05 p.m.—34. **Recent Developments in Rubber-to-Metal Bonding.** Howard H. Irvin, W. H. Cornell, Marbon Corp., division of Borg-Warner, Gary, Ind.

Although for many years brass plating had been the accepted method for obtaining a bond between rubber and steel during vulcanization, resin-type adhesives began to make their appearance on the market about 1939.

These new adhesives were rapidly adopted for many applications and did an excellent job during the war years, when they were used for bonding practically all tank block tread assemblies.

Having done a great deal of the pioneering work in the field of rubber-to-metal adhesives in the late 1930's, the laboratories of Marbon Corp. set out several years ago to develop a new bonding system which would bond most of the stocks that would be encountered in a rubber plant and at the same time would be insensitive to atmospheric conditions (unaffected by ozone, humidity, and temperatures) and to curing cycles (time and temperature).

Such a bonding system has now been developed and is being marketed as Ty Ply "UP" (Universal Primer) and Ty Ply "RC" (Rubber Cover Coat). This two-coat system will bond most natural rubber and GR-S stocks, including Arctic and oil-extended types, and certain nitrile rubber stocks. Ty Ply "UP" will also effectively bond neoprene stocks.

Data on the effect of metal preparation, exposure to ozone or high humidity, and the effect of curing conditions, compound structure, and elastomer plasticity on bond strength are described in detail.

Work has been done to investigate the feeling existing in many quarters that brass plating was to be preferred to adhesive bonding because of greater bond strengths at elevated temperatures and better resistance when subjected to dynamic stresses.

Comparative data are presented on rubber-to-metal bonds prepared by brass plating and by the Ty Ply "UP"/"RC" system, subjected to elevated temperatures, static shock loading, and dynamic stress.

The results confirm the effectiveness of the adhesive system under these conditions.

4:30 p.m.—35. **Variations in Processing and Physical Properties of Oil Masterbatches with Increasing Oil Content.**[9] W. K. Taft, B. G. Labbe, R. W. Laundrie, Government Laboratories, University of Akron, Akron.

A systematic study was undertaken to demonstrate the effect of oil concentration in masterbatched polymers on their processing properties as well as the physical properties of their vulcanizates compounded with three types of blacks at different black loadings. The best balance of physical and processing properties seems to be with raw masterbatch polymer having a Mooney viscosity of about 60 ML-4.

When the Mooney viscosity of the raw masterbatched polymer was lowered by the addition of more oil, poorer stress-strain, rebound, temperature rise, and hardness properties, and lower Banbury temperatures and power consumption resulted with little change in roughness and mill shrinkage. Maintaining higher viscosities of the raw masterbatched polymer by adding less oil affected these properties in the opposite manner. The use of more oil, up to 90 parts to produce lower viscosity masterbatches, improved the Garvey die extrusion, but the use of less oil reduced the extrusion characteristics to the point of being impractical. Reduction of the viscosity by adding more oil increased the optimum cure times and undoubtedly reduced scorchiness.

With masterbatches of equal Mooney viscosity, compounding with an increase in sulfur, depending on the oil content, and a constant acceleration level, regardless of oil content, resulted in a reasonably linear decrease in the following with the increase in oil used: tensile strength, modulus, temperature rise, degree of scorchiness, dump temperature, power consumption, Mooney viscosity of the compound stock, and Shore A hardness. The elongation, rebound, optimum cure, possible flex life, and Garvey die extrusion index tended to increase with increasing oil extension. The other properties did not change significantly with the amount of oil used in masterbatching.

Again with masterbatches of equal Mooney viscosity, compounding to approximately equal hardness by varying black loading did not alter significantly the above-mentioned trends.

Increasing the state of cure of the highly extended polymers by increasing the acceleration level rather than the sulfur level seemed to be preferable as a means of increasing the hardness, modulus, and rebound and decreasing the temperature rise, elongation, set, and time to optimum cure with some loss in flex life, but little or no loss in tensile properties.

[9] The work discussed herein was performed as a part of the research project sponsored by RFC, in connection with the Government Synthetic Rubber Program.

The Third London Rubber Technology Conference

The Third Rubber Technology Conference was held in London, England, at Church House on June 22, 23, 24, and 25, under the sponsorship of the Institution of the Rubber Industry. The Conference was attended by approximately 700 delegates (there were 550 at the 1948 Conference), of whom about 125 were from countries other than Great Britain.

Of the 50 papers presented, nine were from the United States, four were from the Nethlerlands, two each from Malaya and Indo-China, and one each from France, Germany, Australia, Canada, Indonesia, Liberia, and Sweden. The remaining 26 papers were from England.

Lord Baillieu, president of the Conference, presided at the opening on the morning of June 22. He introduced the Marquess of Salisbury, who welcomed the delegates in the name of the Government of Great Britain and expressed the conviction that the Conference would be a great success.

Lord Salisbury called the Conference "a businesslike meeting of experts on rubber —rubber both natural and synthetic" and added that the contacts and exchange of views on joint problems should be to the advantage of everyone. He said he hoped the delegates from abroad would not only benefit from their visit from the purely technical point of view, but would also form friendships that might prove enduring and fruitful long beyond the period of the Conference itself. He then formally opened the Conference, and the chair was turned over to W. J. S. Naunton, who presided during the four days of the meeting.

Social Events

Luncheons were available for the delegates at Church House, and cocktail parties and receptions were held each evening of the Conference. A reception was given by Her Majesty's Government at Lancaster House on June 22. Cyanamid Products, Ltd., held a reception and cocktail party at the Savoy Hotel on June 23. Dunlop Rubber Co., Ltd., gave a reception and cocktail party at the Claridges Hotel on June 24. A reception followed by a banquet presided over by Lord Baillieu, was given by the IRI at the Trocadero Restaurant on June 25.

Chairman of the Conference, W. J. S. Naunton *(Left)*, and Chairman of the Session on Testing Methods, J. M. Buist *(Right)

*All photographs of the Conference, courtesy of *India Rubber Journal*.

The U. S. Delegation

The delegation from the United States included: S. M. Cadwell and B. C. Barton, United States Rubber Co.; J. T. Blake, Simplex Wire & Cable Co.; E. R. Bridgwater, E. I. du Pont de Nemours & Co., Inc.; L. D. Carver, Witco Chemical Co.; W. R. Smith, E. M. Dannenberg, and H. J. Collyer, Godfrey L. Cabot, Inc.; B. W. Henderson, E. W. Cook, and A. R. Davis, American Cyanamid Co.; J. W. Crosby, Thiokol Corp.; I. Drogin, United Carbon Co.; A. E. Juve, The B. F. Goodrich Co.; M. E. Lerner, *Rubber Age*; Leo Mandelkern, National Bureau of Standards; A. A. Morton, Massachusetts Institute of Technology; I. D. Patterson, Goodyear Tire & Rubber Co.; W. B. Reynolds and M. L. Studebaker, Phillips Petroleum Co.; L. Talalay, Sponge Rubber Products Co.; W. Herkness and G. A. J. Voetelink.

Delegates from Canada included N. S. Grace, Dunlop Tire & Rubber Goods Co., Ltd., and L. A. McLeod, Polymer Corp., Ltd.

The Technical Sessions

"Properties of Natural Rubber Latex" was the general subject of the first technical session on the morning of June 22. Of the eight papers comprising this session, six dealt with fresh latex, and two with preserved latex. The importance of differences in phosphate magnesium ratios to the stability of latices was confirmed, and means of determining and removing excess magnesium from unstable latices were reported in one paper. "Lutoids" or viscoids, the yellow-colored, viscous colloid complexes in *Hevea* latex were the subject of another paper. A second paper on mineral elements in latices confirmed the significance of magnesium and phosphorous in connection with stability. A plantation-softened rubber of 35 Mooney viscosity and of exceptional cleanliness was described in another paper. The zinc oxide/ammonia reaction and the zinc oxide testing of preserved latex were covered in two other papers of this session.

"Production and Evaluation of Synthetic Rubber" was the theme of the second session, held the afternoon of June 22 and the morning of June 23. Nine papers comprised this session; one attracting considerable attention was concerned with "graft polymers" in which vinyl monomers are polymerized in natural rubber latex, and the properties of natural rubber widely modified. Other papers covered the mechanism of Alfin polymerization of butadiene; copolymers of butadiene and 2-methyl-5-vinylpyridine as oil-resistant rubbers; copolymers from unsaturated ketones; condensation block copolymers using diisocyanates in which structure can be more readily controlled; long-term oil resistance of synthetic rubbers; and improvement in polymer structure obtained by variations in metal initiator, temperature of polymerization, and in the use of promoters with the initiator.

The **"Chemistry of Rubber"** was the topic for the third session, the afternoon of June 23. The seven papers presented included one on radiation effects in natural and synthetic rubbers and showed that the degree of cross-linking is proportional to radiation dose and is reduced by the presence of styrene or acrylonitrile in copolymers. A study of oxygen-absorption effects in cured and uncured natural rubber showed that the general three-stage type of thermal oxidation curve, with some shifts due to initial curing, presence of antioxidants, etc., is preserved in its basic form. A summary of infrared absorption curves for particular polymer structures was presented in another paper.

The **"Physics of Rubber"** was covered in the fourth session on the morning of June 24 and consisted of eight papers. More work on decreasing the permeability of natural rubber to gases by the use of lamellar fillers; the results of further studies in connection with the statistical network theory of ideal rubber-like materials; nuclear magnetism and the degree of "free rotation" in polymers; natural rubber compounds having low-temperature characteristics of special inorganic elastomers; a model in which hard and soft regions in series is used to explain the stress-strain behavior of filler reinforced vulcanized rubber; and time dependent effects in tire cords, were some of the subjects discussed in this session.

"Developments in Testing Methods" was the theme of the fifth session, held the afternoon of June 24. The six papers included information on the proper machines and techniques for adhesion testing; the constant-power principle in abrasion testing in which it is suggested that a correlation may exist between abrasion and high-temperature flexibility properties of rubber; how variation in contact resistance between adjacent particles of carbon black is related to the electrical resistance of rubber compounds; a laboratory tire cord fatigue tester which duplicates tire cord fatigue characteristics and which causes similar relative strength losses as are found in tires in service; a tire testing machine which will test two tires at a time and coordinate load application or removal with change of speed; and the relaxed compression set test as a quick, easy method for determining the state of cure of vulcanizates.

"Compounding: Theory and Practice" was the subject of the sixth session held on the morning of June 25. The eight papers given at this session included a study showing that the mechanical properties of a rubber compound that are controlled solely by network structure are directly proportional to the number of active sites per unit area and the particle radius. Lignin as a compounding ingredient for natural rubber and the possibility of compounding this material as a dry powder instead of as a latex masterbatch were considered. Equations relating Mooney viscosity with carbon black content and oil absorption for natural rubber and Mooney viscosity with carbon black content, oil absorption, and oxygen content for GR-S were presented in another paper. The reinforcement of natural rubber with formaldehyde-type resins and its extension with oil were the subjects covered by two papers. Intermediate level carbon blacks were reviewed with special reference to their processing, reinforcement, and performances at high temperatures, and the role of particle diameter in rubber reinforcement were covered in two other papers. Rubber-carbon black gel formation was the subject of the final paper of this session.

"Miscellaneous Technology" was the final subject for the seventh session, the afternoon of June 25. Its four papers dealt with tires and tire technology. It was suggested in one paper that abraded tire cord provided better rubber fabric adhesion. Heat treatment of "Terylene" polyester fiber to provide a satisfactory material for rubber product use was discussed in another paper. This session concluded with papers on a study of tires and how they act at high speeds and factors important to tread wear and fuel consumption of tires.

Abstracts of Papers

FIRST SESSION—JUNE 22
PROPERTIES OF NATURAL RUBBER LATEX

CHAIRMAN, E. A. MURPHY
DEPUTY CHAIRMAN, E. W. MADGE

13.[1] Micro-Gel in Latex and Sheet Rubber.

R. Freeman, Rubber Research Institute of Malaya, Kuala Lumpur, Malaya.

The rubber hydrocarbon in fresh latex can be dispersed in benzene to form a solution that passes easily through a porosity 1 sintered filter. When this solution is treated with a finely divided absorbent powder, part of the rubber is removed from solution. The powders that have been tried and found effective are $CaSO_4$ (anhydrous), $Ca(OH)_2$, CaO, kaolin, MgO, kieselguhr, charcoal, lamp black, furnace black, and channel black. These materials have nothing in common except a small particle size. The amount of rubber removed varies with the adsorbent used. The actual viscosity of the solutions is not affected by the removal of 10-20% of the rubber present.

Similar results can be obtained by centrifuging the solution at 144,000 g. These results can be explained by assuming that part of the rubber in normal latex is micro-gel, i.e., cross-linked rubber particles of small size.

The micro-gel latices examined by Bloomfield[2] are shown to be a special type of latex in which most of the rubber is present as micro-gel.

Some micro-gel is present in every sample of latex examined. The amount of micro-gel depends on the clone and varies between 5% and 30% of the total rubber. An average value for bulked latex is 15%.

The micro-gel content of a latex can be increased by treating the latex with a redox system as used to initiate polymerization. The increase in micro-gel is accompanied by an increase in the Mooney viscosity of the dried rubber.

Micro-gel is not affected by coagulation and smoking of the sheet. In freshly prepared smoked sheet the micro-gel content is similar to that of the original latex. On storage the micro-gel is no longer detectable, but a macro-gel component appears.

The particle size of micro-gel has been estimated as 0.1-mμ. This is smaller than the size of the latex particles from which the micro-gel was derived.

14. Production of Improved Rubbers by the Enzymatic Deproteinization of Skim Latex.

J. E. Morris, RRIM.

The proteins in skim latex can be decomposed by proteolytic enzymes. By using animal pancreatic enzymes the protein content of the skim rubber product may be reduced to that of normal smoked sheet. The optimum deproteinization conditions for fresh skim latex have been found to be pH 9 and a temperature of 38-45° C. Calcium ions in 0.02-M concentration give a marked activation of the deproteinizing enzyme. The extent of protein removal cannot be predicted from the skim latex dry rubber, total solids, or protein contents. The copper content of skim rubber is usually high, and that of enzyme-treated skim rubber is dependent on the digestion pH and temperature. Optimum copper removal occurs at pH 9, but increasing temperature gives an increase in the copper content of the rubber product. Methods of copper reduction are given.

The cost of the deproteinization process and of copper removal is briefly discussed, and the relative activities of 25 commercial enzyme preparations have been determined. Methods of carrying out the digestion on the factory scale are appended.

48. The Stability of Ammoniated Latex and Soap-Stabilized Emulsions

Delegates, L. A. McLeod, Canada *(Left)*; J. Walker, England *(Center)*; and Mrs. McLeod

[1] Numbers preceding abstracts refer to the Third Rubber Technology Conference Paper Preprint Number.

[2] G. F. Bloomfield, *J. Rubber Research Inst. Malaya* (1951), Communication No. 271.

in the Presence of Complex Zinc Salts. T. S. McRoberts, British Rubber Producers Research Association, Welwyn Garden City, Herts., England.

The solubility of zinc oxide in solutions of ammonia and different ammonium salts has been determined. The interaction between ammonium laurate and zinc amine (or ethylene diamine) salts has been studied in aqueous solution, in latex, and in oil emulsions.

The results indicate that destabilization of ammoniated latex or soap-stabilized emulsions by dissolved zinc oxide is due to the presence of zinc diamine ions, which form insoluble dilaurates. It is suggested that the increased rate of destabilization at elevated temperatures is most probably due to a decrease in hydration of the zinc diamine dilaurate formed at the surface of the rubber or oil particles.

60. **Variability of *Hevea* Latex.** W. L. Resing, Indonesian Rubber Research Institute, Bogar, Indonesia.

A study was made of the differences in composition between a number of clonal latices. Of great importance in connection with the stability of latex were to be considered the differences found in PO_4/Mg ratios.

The properties of the concentrate of a number of clonal latices from different origins were studied in connection with the PO_4/Mg ratio of the field latices.

The disastrous effect of magnesium ions on the processing quality of concentrated latex, especially in case of foam rubber production, was fully confirmed.

A suggestion was made about the proper treatment of such instable latices, as at least in western Java such latices are frequently found.

69. **Zinc Oxide Testing of Latex.** E. W. Madge, H. M. Collier, and J. L. M. Newnham, Dunlop Rubber, Fort Dunlop, Birmingham, England.

Viscosity changes in concentrated latex under different experimental conditions have been investigated; the object was to determine the mechanism of zinc oxide thickening and to find reasons for inconsistencies in correlating results of the zinc oxide thickening or ZOT test with other latex tests. It has been found that small variations in the amount of natural soap are of great importance in the thickening of latex containing zinc oxide, especially at the low ammonia content used for the ZOT test.

The effect of added soap on the ZOT was found to vary from latex to latex and to be different for different soaps. Less than about 0.3% of various soaps, added to latex prior to the zinc oxide, reduced degree and rate of thickening. With more than this amount of soap the thickening depended on the soap used.

A similar investigation was conducted in which the mechanical stability was measured of latices containing varying amounts of added soap and a standard amount of zinc oxide. Again the behavior was found to vary anomalously with amount and type of soap.

The results show that new tests for the zinc sensitivity of latex must take into account a number of hitherto unsuspected factors, particularly when such tests are required to have a bearing on processing behavior.

79. **The Structure of *Hevea* Latex and Its Viscosity.** G. Verhaar, Firestone Plantations Co., Liberia.

Fresh *Hevea* latex is characterized by the presence of viscoids of greatly varying size (5-200 microns). When the viscosity of such a latex is determined with a viscometer of the rotary type, the values found cover a wide range, with no clear relation to the initial DRC of the latex. Also with the aid of a rotary viscometer the structural viscosity of fresh or any other type of latex can be clearly demonstrated. When fresh *Hevea* latex is treated with ammonia in increasing amounts, there is a sharp and regular drop in viscosity up to 0.05% NH. This runs parallel with a gradual and finally complete disintegration of the viscoids.

Treatment with sodium sulfite in increasing concentrations up to 0.30% yields a more slowly decreasing viscosity with end-values approximately twice as high as with ammonia. Microscopic investigation shows a slow and only partial breakdown of the viscoids in the same area. Formaldehyde gave irregular results, but, in general, did not decrease or increase the initial viscosity considerably; neither could any influence be established on size and shape of the viscoids.

The viscosity of fresh *Hevea* latex is profoundly influenced by addition of distilled water, giving a considerable increase up to 20% and a sharp drop afterward. Latex diluted with 20% of water was microscopically found to be in a stage of precoagulation, with the immobilized rubber particles embedded in the viscoid complexes. It is concluded that the viscoids play a dominant role in viscosity phenomena in *Hevea* latex.

84. **Contribution to the Study of Mineral Elements in Field Latex.** E. R. Beaufils, Rubber Research Institute of Indo-China.

The object of the work reported in this paper is to present basic data concerning the variability of mineral elements in latex.

The latex potassium content is found dependent upon the proportion of serum in the latex. As a rule, when the latex DRC (dry rubber content) level is low, a higher magnesium content is found. The proportion of phosphorus to serum is roughly constant over the year. Calcium content is usually very low, and no relation was found between calcium and DRC variations. More copper % to serum is found during periods when DRC is lower.

Manganese was found as traces only and does not seem to reach harmful levels, at least in Indo-China. Even with copper sulfate injection, which feeds the tapping cut with more copper than the richest soils may give, values never were higher than under natural conditions.

Latices high in magnesium give more frequent premature coagulation and *vice versa*. The stability of field latex is undoubtedly increased by copper sulfate injection, which increases phosphorus content and can decrease the proportion of magnesium.

The stability of fresh latex and the mechanical stability of centrifuged latex are clearly distinct problems. Both magnesium and phosphorus seem responsible in both cases.

85. **Considerations about Rubber Peptized at the Plantation.** G. Giger and J. Lemee, Institut Français du Caoutchouc, Paris, France, and M. Liponski, Institut des Recherches sur le Caoutchouc en Indochine.

The production of plantation-peptized rubber on an industrial scale has been going on for a number of years.

In order to estimate the benefits conferred upon the user by the employment of this type of rubber, it has been compared with rubber plasticized on mixers of different types and sizes, such as laboratory and industrial types of open mill and internal mixers. The comparison included smoked sheets, plasticized during milling, with and without simultaneous addition of peptizer, and, finally, soft rubber peptized at the plantation.

The results obtained confirm and define more clearly the remarks made by preceding authors, i.e., that the utilization of peptized rubber, used in preference to smoked sheets, insures a substantial reduction at the peak load appearing at the beginning of the mixing, as well as a reduction in plasticization time and overall power consumption during the process.

The problem was to determine whether the additional expense incurred by the production of peptized rubber was lower than the savings made through its use. In most cases the answer seems to be positive; the difference becomes increasingly marked as the user's plasticization equipment is less powerful. Moreover, the greater the breakdown required, the greater is the advantage of using plantation peptized rubber.

This reason led us to develop the preparation of a type of rubber characterized by its low viscosity. The methods of preparation, as well as the properties of the product, are discussed.

Since the Mooney viscosity of the rubber obtained may be lower than 50, it will be necessary to provide a special type of packing; this will naturally increase the costs, but the absolutely dirt-free rubber obtained amply compensates for any such expenses.

Second Session—June 22 and 23
Production and Evaluation of Synthetic Rubber

Chairman, W. J. S. Naunton
Deputy Chairman, J. T. Watts

1. **Cation and Anion Influence in the Alfin Reagent for the Polymerization of Butadiene.**[3] Avery A. Morton, Irina Nelidow, and Emanuel Schoenberg, MIT, Cambridge, Mass.

A mixture of allylsodium, sodium isopropoxide, and sodium chloride causes a very rapid polymerization of butadiene to a soluble polymer of unusually high molecular weight which has largely a 1,4-structure. The present work is a study of the influence of the sodium cation and of various halide salts, and of the isopropoxide ion as contrasted with the n-propoxide, upon the proportion of 1,4-polymerization.

A proper combination of ions will favor greatly the end to end polymerization, and any given reagent may cause either 1,4- or 1,2-polymerization to take place, depending on the composition of the reagent. An explanation based on adsorption and orientation of diene molecules on the surface of the insoluble aggregate of ions is suggested

7. **How Synthetic Rubbers Affect You.** Ian D. Patterson, Goodyear, Akron, O.

Synthetic rubbers have found their place in the economy of war and peace. Their continued production is indicated as necessary for progress in the world's welfare.

Tough, high molecular weight polymers, made usable by masterbatching with oil, have proved their superior quality and economy by three years' application on a large scale. The Olsen flow test has been added as a means for choosing better

[3] This work was performed as part of the research project sponsored by the Reconstruction Finance Corp., Office of Synthetic Rubber, in connection with the Government Synthetic Rubber Program.

polymers capable of holding larger amounts of oil and for adhesives.

High solids butadiene/styrene copolymer and butadiene polymer latices have improved in quality so that they can be used in larger amounts for foamed rubber products. An evaluation of their status is indicated.

Medium and low solids butadiene/styrene latices have been successful as base ingredients for adhesives and paints. The Olsen flow test has been useful in coordinating properties of the polymer with needs of end-use in adhesives.

Types of agitation, reactors, concentrators, heat exchangers, batch and continuous polymerization have been important contributions in the chemical engineering phase of the program.

17. **Pyridinium High Polymers—A New Class of Oil-Resistant Synthetic Rubbers.** W. B. Reynolds, J. E. Pritchard, M. H. Opheim, and Gerard Kraus, Phillips Petroleum, Bartlesville, Okla.

Delegates (left to right): A. V. Howson, F. A. Jones, J. T. Watts, W. A. Gurney, W. McG. Morgan, W. P. Fletcher, and R. G. Newton, All of England

Copolymers of butadiene and 2-methyl-5-vinylpyridine are readily "vulcanized" by heating in the presence of organic halides. The number of effective cross-links can be readily calculated from moduli of swollen stocks using the network-statistical theory of rubber elasticity. Cross-linking depends upon the amount and the activity of the quaternizing agent. However, even at low levels of halide, it appears that several quaternary groupings are necessary for each effective cross-link. Zinc oxide greatly increases the swollen moduli of the copolymer-halide systems. But sulfur and accelerator alone have little effect on the same system, and these agents do not further increase the swollen moduli of the ternary system, copolymer-halide-ZnO.

38. **Rubbery Copolymers from Unsaturated Ketones,** W. Cooper, T. B. Bird, and E. Catterall, Dunlop Rubber.

The preparation and properties of copolymers from unsaturated ketones with acrylate esters and with butadiene are described.

Details of the polymerization reactions and the structure of the copolymers are given. The preparation and the properties of compounded vulcanized polymers are described, and, in the case of the ketone-acrylate copolymers, the mechanism of sulfur vulcanization is discussed.

37. **The Preparation and Some Properties of Condensation Block Copolymers.** D. H. Coffey and T. J. Meyrick, Imperial Chemical Industries, Ltd., Manchester, England.

By using diisocyanates to link together two different polyesters having terminal hydroxyl or carboxyl groups, copolymers have been obtained in which the two repeating units occur in blocks and not in the random arrangement obtained by normal methods of preparing copolymers.

Melting points have been measured by a penetrometer method, and the effect of copolymer composition on melting point was determined. In a series of crystalline copolymers made by linking various amounts of polyethylene sebacate and polyethylene adipate with hexamethylene diisocyanate, a step-shaped melting point *vs.* composition curve is obtained; copolymers containing up to about 40% of polyethylene adipate have the same melting point as that of polyethylene sebacate; further increase in the polyethylene adipate content results in a rapid drop in melting point until the melting point of polyethylene adipate is reached; thereafter increasing amounts of polyethylene adipate do not alter the melting point. Random copolymers of ethylene adipate and ethylene sebacate give a V-shaped melting point *vs.* composition curve. The step-shaped curve of block copolymers is almost identical with the melting point *vs.* composition curve of melt blends of the two polymers.

Stress-strain characteristics and impact strengths of the block copolymers have been measured. In the polyethylene adipate/polyethylene sebacate/hexamethylene diisocyanate series no great differences are found between random and block copolymers. If, however, the crystalline polyethylene adipate is replaced by the non-crystalline poly-propylene adipate, then block copolymers containing 15-30% of polypropylene adipate have outstanding impact strength. Similar high-impact strength is obtained by using a compatible rubbery polymer as an external plasticizer with hexamethylene diisocyanate modified polyethylene sebacate.

This method of block copolymerization has an advantage over random copolymerization in that a crystalline copolymer can be modified without reduction of its melting point, and by suitable selection of a second component it affords a means of "building in" a plasticizer.

50. **Graft Polymers Derived from Natural Rubber.** G. F. Bloomfield, F. M. Merrett, F. J. Popham, and P. McL. Swift, BRPRA.

When vinyl monomers are polymerized in the presence of rubber under suitable conditions, some of the polymeric chains become attached to rubber molecules, and a "graft polymer" is obtained. The products contain a varying amount of free polymer formed concomitantly with the graft polymer, but do not contain any free rubber provided a suitable proportion of vinyl monomer is used. In this way the properties of natural rubber can be widely modified according to the nature and the amount of the grafted polymer, and, in particular, when hard polymers are so incorporated their already known reinforcing effect is supplemented by the advantages obtained by having a considerable proportion of polymeric filler chemically linked to the rubber. Some of the modified materials, more especially those made from polar monomers, have rather unusual solubility characteristics arising from the different behavior toward solvents of the polymer and rubber components of the molecules.

Experimental methods specially developed for the characterization of the products firmly establish the graft-polymer structure. Study of the influence of the type of polymerization catalyst has indicated that the polymer-modified rubbers so far studied appear to be produced by direct growth of polymer chains on to rubber molecules rather than by a transfer reaction involving the rubber.

Graft polymers of styrene and methylmethacrylate with rubber can be readily compounded and cured to give light-colored articles of good tensile strength, and attention is drawn to the outstanding flex-cracking and fatigue resistance of rubber-methyl-methacrylate graft polymers. The properties of vulcanizates based on various other polymers are briefly reviewed in the paper. Rubber modified with ethyl acrylate is difficult to vulcanize and is more resistant to oxidation than raw rubber.

Progress in the wider field of modification of rubber by combinations of polymerizing monomers is reviewed.

46. **Oil Resistance of Synthetic Rubbers over Very Long Periods of Time.** Bo Sarnö, AB Liljeholmens Kabelfabrik, Stockholm 9, Sweden.

The purpose of this investigation was to study the long-term oil resistance of synthetic rubber gaskets used in transformers and similar apparatus. For such equipment a long and reliable service life is essential, as a failure will cause an expensive break in the electricity supply. The cost of replacement and oil losses

may be considerable for big transformers. In view of the nature of the investigation it was natural to concentrate the study on practical compounding and to leave out purely scientific problems. Compounding principles recommended by the synthetic rubber manufacturers were mainly followed. Vulcanized slabs were immersed into hot transformer oil until they had lost their rubber properties.

When a big transformer is fully loaded, the top has a temperature of up to 85° C. In most cases the gaskets have a somewhat lower temperature, generally not exceeding 70° C. Therefore the latter was chosen as the testing temperature; some supplementary tests were, however, made at 20 and 100° C., and for polyacrylic rubbers even at 150° C. The duration of the immersion period has been dependent upon the changes in the rubber properties during the test and in some cases extended to 14 years.

The polymers studied were the neoprenes, the Swedish chloroprene rubber, Svedoprene, German and American Perbunan, and the Hycars. The influence of compounding ingredients was investigated to a certain extent, and some attention was given to the effect of the vulcanized rubber on the dielectric properties of the oil.

67. **Structure and Solution Properties of High Molecular Weight Butadiene-Styrene Copolymers.** R. B. MacFarlane and L. A. McLeod, Polymer Corp., Sarnia, Ont., Canada.

Production of high molecular weight copolymers of butadiene and styrene for use in oil-extended rubbers has aroused interest in the solution properties of copolymers above the molecular weight range commonly encountered in commercial practice. It has been observed that solubility of such polymers in toluene is a time-dependent phenomenon, and the apparent solubility can increase continuously, in the absence of agitation, for as long as 800 hours. Although a standard Harris cage solubility test may show the presence of 50% gel, other properties do not confirm the presence of any appreciable quantities of insoluble material. Mild agitation rapidly promotes almost complete solubility. Dilute solution viscosity measurements are very misleading unless the influence of solution time is recognized and apparent intrinsic viscosities rise progressively with time of contact of the sample with solvent.

This time-dependence of solution has been found to occur at conversions higher than 50% and is also a function of the amount of modifier used in the polymerization recipe. It has not been possible to shorten the solution time for viscosity measurements by mild heating or gentle agitation. Mixed solvents cause a change in the amount of increase of the apparent intrinsic viscosity, but do not shorten the time to equilibrium.

Measurement of the slope constant in the Huggins viscosity equation indicate that these solubility and viscosity effects coincide with the appearance of a marked degree of branching in the polymer molecules. The effect is, therefore, interpreted as being caused by the relatively slow disentanglement of molecules of complex structure.

75. **Recent Studies on the Structure of Synthetic Rubber.**[3] R. F. Dunbrook, B. L. Johnson, J. L. Binder, J. M. Willis, and E. L. Carr, Firestone Tire & Rubber Co., Akron.

Synthetic rubber research workers have sought diligently to reproduce the structure of natural rubber and thereby evaluate the characteristics believed to be responsible for its good tread wear, high "gum" strength, and low hysteresis. Tread wear superior to that of natural rubber has been achieved in low-temperature polymer (LTP) despite the fact that its structure is not at all like that of natural rubber. It is postulated that the improvement in tread-wear resistance of LTP GR-S over that of hot GR-S is a result of the smaller amount of low molecular weight material found in LTP. It has been found possible to obtain the LTP-type molecular weight distribution in polymerization at 122° F. by use of diazo initiators (Nitrazole CF and AIBN) and also by other means. These polymers have wear resistance equal to LTP.

The microstructure considered necessary to duplicate the performance of natural rubber in other respects includes high linearity (1,4-addition) for high gum tensile strength and the *cis* configuration for retention of physical properties at high temperatures together with suitable physical properties at room temperature and below. A large amount of work carried out in the field of emulsion polymerization has shown that changes in the recipe have little effect on the microstructure of GR-S type of synthetic rubber. It now appears that polymer structure can be influenced much more readily and to a greater degree by alkali metal initiation. These structural changes in polymers are produced by variations in metal initiator, temperature of polymerization, and in the use of promoters with the initiator.

THIRD SESSION—JUNE 23
CHEMISTRY OF RUBBER

CHAIRMAN, L. C. BATEMAN
DEPUTY CHAIRMAN, W. C. DAVEY

9. **Studies in Latex Particle Surface Reactions: Kinetics of Hydrochlorination of Unvulcanized and Vulcanized Latices.** Manfred Gordon and James S. Taylor, Royal Technical College, Glasgow.

In the van Veersen hydrochlorination of latex, two stages, associated with different reaction loci and mechanisms, are distinguishable: a "surface reaction" in an outer shell and a "bulk reaction" inside the particle. The rate control of the two mechanisms is briefly discussed. The surface reaction stands isolated at low pressures of HCl and is measureable down to about 0.08-atm. of HCl gas. The surface reaction affects only about 2% of the rubber in *Hevea* latex, but up to more than 20% of synthetic or selectively creamed *Hevea* latex with sufficiently fine particles.

The saturation of double-bonds at the surface locus proceeds in an inward direction from the particle surface and is limited to about the outer four layers of polymer chains. This restriction is due to the instabiilty of the diffusing reagent in the rubber medium, which also accounts for the enormous nominal reaction order of the surface reaction. This order was found to be about 26 in one run; while the bulk reaction follows zero order kinetics.

The kinetics of the isolated surface reaction is shown to be a useful tool in studying the unsaturation of the surface layers in prevulcanized latex. By its means it is proved that a surface reaction can also affect latex vulcanization. This point is technically important, because the film strength of latex decreases critically with increasing vulcanization of the particle surface.

Brief generalized conclusions concerning the significance of kinetic studies on latex reactions, and particularly of the rate control, are appended.

35. **Oxygen-Absorption Effects in Cured and Uncured Natural Rubber.** R. L. Stafford, ICI.

The general three-stage type of thermal oxidation curve is discussed. It is shown that the effects on oxygen absorption of initial degree of cure of the compound, the temperature of oxidation, and the presence of compounding ingredients such as antioxidants, can very largely be described in terms of a relative shift of the three stages of oxidation, the basic form of the oxidation curve being preserved.

Experiments are discussed in which oxygen absorption is measured during the onset of sulfur combination; from these it appears that high rates of oxygen absorption are intimately connected with high rates of sulfur combination and that the initial high-rate stage of the typical oxidation curve reflects the continued curing of the compound.

The above considerations affect the relative assessment of antioxidants, both by oxygen absorption and conventional accelerated aging tests.

With raw natural rubber it is shown that the past history of the test piece very largely determines the type of thermal and photo-oxidation curve subsequently observed. Photo-oxidation experiments are discussed in which the control films used were made from latex which had been tapped and stored in the dark; the rubber received its first exposure to illumination in the oxygen-absorption apparatus.

The effect of milling on raw rubber activates both thermal and photo-oxidation; the activation is subject to a decay process which complicates the interpretation of oxygen-absorption data.

39. **Infrared Spectroscopic Analysis of Elastomers.** W. H. T. Davison and G. R. Bates, Dunlop Rubber.

Infrared absorption spectroscopy is the most generally applicable technique available for the analysis of elastomers and other polymers encountered in the rubber industry. The emphasis of this paper is on the general identification and estimation of a wide range of elastomers, rather than the accurate quantitative analysis of particular copolymers and mixtures.

The theoretical basis of spectra, particularly of polymers, is described. The additivity of absorbances is the basis of quantitative analyses, for which the procedures are outlined. Although theoretically some interaction between repeating units is to be expected, most repeating units have the same spectra whether in homopolymers or copolymers.

Experimental techniques are described for preparing samples for spectroscopic examination from both uncured and cured materials. The latter, particularly when reinforced with carbon black, often give difficulty since they transmit insufficient energy for direct examination. As an alternative to solution or pyrolysis, a reflecting microscope may be used to increase the amount of energy available for measurement of the spectrum.

Spectra of a large number of homopolymers, copolymers, and mixtures are reported from 650-3,600 $cm.^{-1}$, mostly in simplified line form. Polymers covered include polydienes, polyvinyl and isopropenyl compounds (including polyketones and acrylates), polyesters, polyurethanes, modified polyethylenes and silicones.

A summary of absorptions characteristic of particular polymer structures is given in the form of a correlation chart.

The limitations of the technique are discussed, and probable future developments are suggested, i.e., extension of the spectral range below 650 $cm.^{-1}$, improved tech-

Delegates *(Left to Right)*: A. E. Juve, U.S.A.; Dr. Naunton; S. M. Cadwell, U.S.A., and Mrs. Cadwell; B. C. Barton; W. R. Smith, John Andrews, and H. J. Collyer, All from the U.S.A.

niques of sample preparation, and combinations of spectroscopy with chemical procedures such as pyrolysis.

51. **Structural Characteristics of the Sulfur Linkage in Natural Rubber Vulcanizates.** L. Bateman, R. W. Glazebrook, C. G. Moore, and R. W. Saville, BRPRA.

Polyisoprenes react with sulfur both intramolecularly and intermolecularly to yield cyclic sulfides and cross-linked sulfides respectively. The structures of these have been examined for the reaction of the diisoprene, 2:6-dimethylocta-2:6-diene, with sulfur at 140° C. The cyclic sulfides consist of the two saturated compounds (I) and (II) and the two unsaturated compounds (III) and (IV). The cross-linked sulfide consists of a complex mixture in which unsaturated open-chain and saturated and unsaturated cyclic sulfide structures have been identified. The structures of these products suggest a polar reaction mechanism, and also that hydrogen sulfide participates in the reaction.

The influence of organic bases, the sulfurizing agent, reaction temperature, and zinc salts on the nature of the sulfur linkage is discussed.

57. **The Behavior of Highly Filled Rubber Vulcanizates.** K. C. Bryant and D. C. Bisset, Monsanto, London.

The examination of the stress-strain curves of vulcanizates containing up to 60% v/v of mineral filler of particle-size greater than 1 mμ has led to the discovery of a "plateau" at which the elongation increases several hundredfold at constant stress. This point has been demonstrated for a number of fillers with several rubbers, natural and synthetic. The effect of filler content, particle-size, degree of cure, on the stress at which the plateau occurs, and its length have been investigated. An explanation is suggested, and the significance of the observations for the experimental verification of equations relating modulus to filler content is pointed out.

The volume changes accompanying the elongation of these vulcanizates have also been investigated at varying filler contents, particle sizes, and degrees of cure and are shown to correlate with the stress-strain curves.

The possible bearing of these results on the nature of the rubber-filler bonds, and hence on the reinforcing action of fillers, is briefly discussed.

82. **Some Chemical Reactions of Antioxidants Used in Vulcanized Rubber.** P. Schneider, Farbenfabriken Bayer, A.G., Leverkusen, Germany.

The work by Farmer and other authors has shown that the oxidation of unsaturated polymers proceeds via primary-formed hydroperoxides. The addition of antioxidants, including chiefly compounds of the class of the phenols and secondary aromatic amines, makes it possible to delay to a great extent the chemical changes taking place on unsaturated compounds. The mechanism of the action of phenols on the oxidation has been explained by Bolland.

It is difficult to separate from the polymer the reaction products formed from the antioxidant by the dehydrogenating action of the polymeric hydroperoxide radical. In view of the fact, however, that the kinetics of oxidation in the presence of added peroxide corresponds to the autoxidation of the unsaturated compound, the reaction between phenols or secondary aromatic amines and organic or inorganic oxidation agents has been studied in detail by several workers.

Depending on type, position, and number of the substituents, different reaction products are formed from phenols. Diphenylamine reacts with manganese dioxide to form a mixture of N,N′-diphenylbenzidine and the corresponding quinonedianil. N,N′-tri-β-naphthyl-1,2-naphthylenediamine is formed from β-dinaphthylamine with potassium permanganate; whereas under equal conditions N-phenyl-β-naphthylamine forms N,N′-diphenyl-N-2-naphthyl-1,2-naphthylenediamine.

Starting from the deduction that the chemical reaction products of the antioxidants accumulate on the surface of the vulcanized rubber owing to decreasing solubility, pure gum stocks of cured natural rubber containing diphenylamine, N-phenyl-α- and β-naphthylamine have been exposed to atmospheric conditions for eight months. The dark-colored reaction products could be removed mechanically from the surface of the cured goods after having been wet with methanol. After evaporation, the residue was taken up in ethylidene chloride, and the resulting solution evaporated to dryness. Amorphous mixtures of brown-colored compounds were isolated from the vulcanizate containing diphenyl-amine and N-phenyl-β-naphthylamine; the reaction products of the N-phenyl-α-naphthylamine were obtained as a dark-colored tar.

In addition to other compounds, the presence of the N,N′-diphenyl-N-2-naphthyl-1,2 naphthylenediamine was proved by paper partition chromatography of the resulting azodyestuff obtained from the mixture of the reaction products from N-phenyl-β-naphthylamine by coupling with diazotized 1-aminonaphthalene trisulfonic acid. The presence of this compound had also been shown by the UV-spectra. In the same manner, small quantities of the N,N′-diphenylbenzidine could be recognized from the corresponding azodyestuff formed from the reaction product of diphenylamine. Owing to extensive oxidation, the presence of reaction products could not be proved in any appreciable quantity from the reaction mixture of the N-phenyl-α-naphthylamine.

87. **Cross-Linking and Radiation Effects in Some Natural and Synthetic Rubbers.** A. Charlesby and Miss D. Groves, Atomic Energy Research Establishment, Harwell, England.

When subjected to atomic energy radiation, certain polymers cross-link, a process which is equivalent to vulcanization, but which occurs without the admixture of extraneous chemical agents. Other polymers degrade by main chain fracture, a process which occurs at random throughout the molecule and is different from thermal or ultra-violet degradation.

Of the various methods available for detecting cross-linking in irradiated polymers, two, based on solubility and swelling, have been used to study the effect of high-energy radiation on a number of natural and synthetic rubbers. The materials investigated include natural rubber, polychloroprene, polyisobutylene, butadiene, and thioplasts, as well as a number of copolymers. The results obtained show that the degree of cross-linking is proportional to radiation dose and is reduced by the presence of styrene or acrylonitrile in copolymers.

Possible applications of this physical technique of linking molecules are discussed briefly.

FOURTH SESSION—JUNE 24
PHYSICS OF RUBBER

CHAIRMAN, J. R. SCOTT
DEPUTY CHAIRMAN, L. MULLINS

6. **Modifications of the Permeability of Natural Rubber Vulcanizates.** P. Thirion, Institut Français du Caoutchouc.

Vulcanizates with a low permeability may be obtained by incorporating into natural rubber mineral fillers or other elastomers.

Thus the relative permeability of mixtures containing 20 vol. % of ordinary fillers is, compared to a pure-gum compound, generally between 83 and 59%; while the permeability of mixtures containing the same proportion of mica powder or other special fillers such as bentones may vary between 52 and 21%. Temperature and the nature of the gas will only have a very slight influence on these values.

When we try to explain the permeability reduction from strictly geometrical considerations, however, we are faced with the fact that mixtures containing ordinary mineral fillers, such as chalk, have a greater permeability than is predicted theoretically.

The incorporation into natural rubber of other elastomers of low permeability does not reduce the permeability so effectively as the addition of lamellar fillers. Besides factors such as the relative concentrations and the permeability of the components, another factor intervenes, which characterizes the colloidal structure of the mixtures of elastomers.

24. **Reinforcement and Tear Strength Anisotropy.**[4] H. J. J. Janssen, Rubber Stichting, Delft, Holland.

Anisotropy in respect to tearing of natural rubber-carbon black compounds after prestretching can be demonstrated with the Delft tear test method. Possible effects of this tear strength anisotropy on the problem of reinforcement—especially for the type of abrasion leading to Schallamach's abrasion pattern—are discussed.

It appears that, if it is permissible to extrapolate the results found under slow extension to the conditions encountered during service, the tear strength anisotropy of natural rubber-carbon black compounds would be beneficial to reinforcement against tearing, but disadvantageous to reinforcement against abrasion.

76. **Elasticity of Ideal and Real Rubber-Like Materials.**[5] Hubert M. James, Purdue University, West Lafayette, Ind., and Eugene Guth, University of Notre Dame, Notre Dame, Ind.

The assumptions and stress-strain relation of the statistical network theory of ideal rubber-like materials are briefly surveyed. It is pointed out that the stress-strain relation corrected for thermal expansion is similar to van der Waals' equation for a real gas. Recent accurate measurements at Notre Dame on dry gum stocks check the theoretical stress-strain relation for extensions from 1% to 15%.

A new model for real rubbers is described briefly. This model includes intermolecular forces of van der Waals' character which tend to establish definite orientations of next-neighbor links with respect to each other. This model shows orientational melting; its theoretical treatment is similar to the internal Weiss field treatment of ferromagnetism. The present paper deals only with the stress-strain relation valid at temperatures well above the melting range. This stress-strain relation contains two new stress terms, in addition to the term of the ideal rubber theory. Similar terms appear in the theory of "non-Gaussian networks," as corrections for the finiteness of the chains, but show a temperature dependence different from the terms due to chain interactions. Terms of both types should appear in the theory of real rubber. Accurate stress-temperature measurements on dry and swollen rubbers may permit separation of these terms from each other.

77. **Study of Rubber-Like Polymers by Nuclear Magnetism.**[5] B. A. Mrowca and E. Guth, University of Notre Dame.

The method of nuclear magnetism made possible for the first time a direct observation of the degree of "free rotation" in polymers. The actual width of the proton resonance line in uncured natural rubber has been determined at room temperature. It is about 30 times larger than the actual width in water. Cure increases the line width. For natural rubber the increase is perhaps compatible with a physical bonding rather than the usually assumed chemical cross-linking. For a butadiene-styrene copolymer, the increase in line width due to cure is somewhat larger. Carbon black loading increases the line width to a lesser degree than cure. This finding is compatible with the concept of physical bonding between the blacks and the polymer chain molecules.

The effect of both cure and loading is being further investigated at low temperatures (down to —170° C.) so that more reliable conclusions can be drawn. Nuclear magnetism is also well suited for studying the change in the degree of free rotation caused by changes in chemical composition and copolymerization.

[4] Communication No. 257, Rubber Stichting.
[5] Supported in part by U. S. Office of Naval Research

Polypropylene and polypropylene oxide of roughly the same average molecular weight are compared. The polypropylene oxide exhibits a greater degree of "free rotation" about its C-O bonds than polypropylene does about the C-C bonds. Two butadiene-acrylonitrile copolymers and the isocyanate cross-linked polyester, Vulcollan, have also been studied as a function of temperature. Finally, the spin-lattice relaxation time *vs.* temperature studies are reported for a butadiene-acrylonitrile copolymer and for raw Butyl. Conclusions about the magnitude of the barriers hindering free rotation are drawn both from the spin-lattice relaxation times and from the line width data.

47. **Natural Rubber Compounds for Intermittent Low-Temperature Service.** W. P. Fletcher, A. N. Gent, and R. I. Wood, BRPRA.

The provision of natural rubber compounds for service at very low temperatures requires the solution of two problems. The first is concerned with the immediate changes in physical properties such as stiffness and hysteresis which occur when the temperature of the elastomer is lowered. The second arises from slow changes in stiffness, associated with crystallization, which may be significant if the rubber is stored for long periods under strain at low temperatures.

This paper is concerned with the first problem and describes a simple test method based on the torsional pendulum which may be used to measure the stiffness and mechanical loss factor of a rubber compound at temperatures down to —120° C. and which is capable of following the complete transition from the rubbery to the glassy state. Rubber compounds may be characterized by a critical temperature, i.e., the temperature at which the stiffness is increased by a given factor (e.g., 2, 10, 100) with respect to the 20° C. value, or by the temperature at which a maximum occurs in the loss factor *vs.* temperature plot.

In order to produce compounds having better overall low-temperature performance than that exhibited by a simple compound of the same elastomer, suitable plasticizers are required. Numerous materials have been examined, and some are satisfactory in producing critical temperatures far below those shown by unplasticized natural rubber. Special compounding techniques which prevent molecular degradation of the rubber have been developed. These allow the addition of the necessary quantity of plasticizer while maintaining a high standard of general physical properties. Typical practical compounds of various hardnesses have low-temperature characteristics approaching those of the special low-temperature types of inorganic elastomers coupled with markedly superior physical properties.

49. **Theoretical Model for the Elastic Behavior of Filler-Reinforced Vulcanized Rubbers.** L. Mullins and N. R. Tobin, BRPRA.

The stress-strain properties of both pure gum and filled vulcanized rubbers have been studied in simple extension and their dependence on previous deformation has been examined. It is shown that both the increased stiffness produced by fillers and the softening which results from deformation can be interpreted in terms of a simple two-phase system.

The filler-reinforced vulcanizate can be considered to be composed of zones of hard and soft rubber. On the application of a stress, most of the deformation takes place in the soft regions whose elastic behavior can be described in terms of the classical theory which has been developed for highly elastic materials. The hard regions make little contribution to the deformation, but are broken down to form soft regions by the application of sufficient stress. The fraction of the rubber in the soft state thus depends upon the maximum stress previously applied.

The stress-strain behavior of the composite material can be represented most simply by a model in which the hard and soft regions are in series, and in which, to a first approximation, the hard regions are assumed to be inextensible. The observed deformation at any stress is proportional to the fraction of the rubber in the softened state.

Analysis of the stress-strain curves of filler-reinforced vulcanizates measured both before and after previous deformation has shown that it is possible to describe their course in terms of (1) a stored energy function given by high elastic theory and appropriate to the rubber matrix; (2) a single parameter which gives the fraction of rubber in the softened state and is a function of previous deformation.

In particular, each stress-strain curve obtained on any filler vulcanizate system at elongations less than the previous maximum elongation can be superimposed on that of the rubber matrix by multiplying the strains by the appropriate factor given by the parameter above.

59. **Non-Linearity in the Dynamic Properties of Rubber.** A. R. Payne, Research Association of British Rubber Manufacturers, Croydon, England.

The first two sections of this paper deal with the necessity of amending the classical Newtonian equations by assuming a non-linear stress-strain curve, in order to account for the presence of a considerable amount of second harmonic of the test frequency in the restoring forces in a rubber, in both forced-vibration and positive-displacement dynamic testers.

The non-linear stress-strain curve is applied also to a damped free vibration curve of the Yerzley type and is shown to account for the asymmetry of the envelope of the vibration curve.

The latter part of the paper obtains a relation between the dynamic modulus of loaded rubbers and amplitude of vibration, leading to equations analogous to those used in rheology to deal with rate of shear effects in non-Newtonian liquids, and to explain the effects of fillers on the static modulus and hardness of vulcanized rubbers.

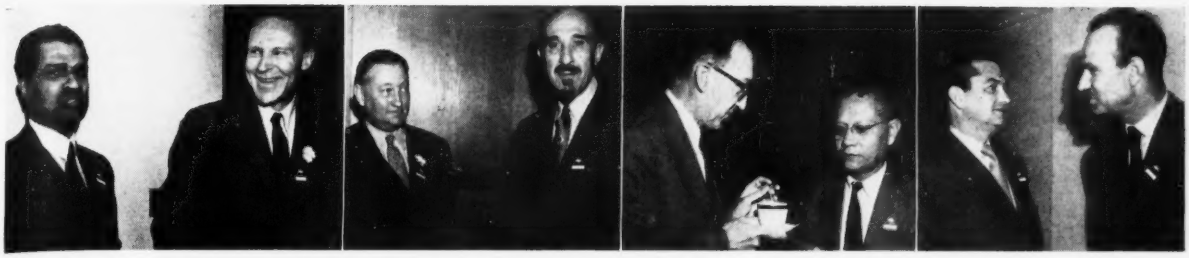
A resonance curve from a resonant vibrator is analyzed, and the variation of modulus with amplitude is shown to exhibit the typical thixotropic effect associated with loaded rubbers subjected to vibrations.

The last section discusses how the decrease of modulus with increasing amplitude can be attributed to two different mechanisms: (1) thixotropic breakdown of filler structure, (2) in compression, non-linearity of the stress-strain curve.

45. **Time Dependent Effects in Tire Cords.** J. O. Wood and W. F. Kilby, Dunlop Rubber.

The significance of time in relation to the mechanical testing and application of textile materials is discussed with special reference to tire cords.

Experimental results for the creep of cotton, rayon, nylon, and Terylene tire cords obtained under different conditions of load humidity and temperature are presented. An increase in relative humidity at constant load and temperature has the effect of increasing the rate of creep of both cotton and rayon, but has little effect upon



Delegates (Left to Right): B. E. R. Pieries, Ceylon; M. W. Phi'pott, England; G. Le Person and H. Woog, France; G. Verhaar; Liberia; G. E. van Gils, Indonesia; R. A. T. Hetzer and Hans Verbeek, Germany

that of the hydrophobic materials, nylon and Terylene. An increase in load, with other conditions being constant, causes an increase in the rate of creep of cotton and rayon. The rate of creep of nylon and Terylene increases with increasing load to a maximum value and thereafter for higher loads decreases to a value which remains almost independent of load. Increase in temperature results in an increase in the rate of creep of all four materials. Heat shrinkage effects which occur in nylon and Terylene are briefly discussed.

The results obtained for rayon are discussed in the light of modern theories relating to the mechanical properties of textiles. A tentative value for the activation free energy of flow of about 30,000 cal./mole is derived for rayon, which is of the order of magnitude obtained by other authors.

Other time-dependent effects, such as the dependence of breaking strength, extensibility, and work to rupture of tire cords upon rate of loading, are discussed, and some experimental results are presented.

FIFTH SESSION—JUNE 24—DEVELOPMENTS IN TESTING METHODS

CHAIRMAN, J. M. BUIST
DEPUTY CHAIRMAN, L. MULLINS

41. **Tear-Down Adhesion Testing.** B. Pickup, Dunlop Rubber.

The force required to strip adhering materials apart at constant speed fluctuates rapidly as stripping proceeds. In order to measure and record these fluctuations a testing machine must have a high natural frequency and appropriate damping. A laboratory experimental model of a suitable machine is described.

It is customary to perform the tear-down test on a high inertia tensile-testing machine. Such a machine, because of its low natural frequency and light damping, cannot validly record the fluctuations in the stripping force. Many practical tests prove this point and also show that the new machine is satisfactory.

Since it is important in practice to measure the variability of the tear-down force—and to express it in statistical terms—all tear-down testing should be performed on machines incorporating the necessary frequency and damping conditions. The choice of natural frequency and damping is discussed, and some suitable values are quoted.

42. **Constant Power Principle in Abrasion Testing.** E. F. Powell and S. W. Gough, Dunlop Rubber.

Many different types of laboratory abrasion test are in regular use for assessment of wear resistance, and one underlying principle is proposed as a criterion for comparison of the validity of test design. This is the principle of constant rate of energy dissipation at the abrading surface.

The details of a modification to the well-known Lambourn constant slip machine, to make it conform with the constant power principle, are described, and the degree of correlation with service data on tires is given.

When this modified machine has been used, the effects of several major variables on the abrasion loss of rubber tread compounds are reported. Extensive work on combating stickiness is outlined.

Experiments are reported with other well-known machines, such as the du Pont and Bureau of Standards abraders, modified to conform with constant power principles.

In addition, some speculations are put forward about relations between the work done in mechanically grinding rubber and the energy associated with the bonds ruptured in the grinding action. Arising from these, it is suggested that a correlation may exist between abrasion and high-temperature flexibility properties of rubber.

43. **Changes of Electrical Resistance of Rubbers Loaded with Carbon Black.** D. G. Marshall Dunlop Rubber.

The changes in electrical resistance accompanying the deformation of electrically-conducting natural rubber, Butyl rubber, neoprene, and Thiokol FA have been studied under static and dynamic conditions. The results have been interpreted in terms of variations in the contact resistance between adjacent particles of carbon black.

44. **Tire Cord Fatigue and Fatigue Testing.** R. S. Goy, Dunlop Rubber.

A laboratory textile tire cord fatigue tester is described which duplicates tire cord fatigue characteristics and which causes similar relative strength losses as are found in tires in service. Using this tester, it is shown that cord twist plays an important part in the fatigue life of textile tire cords. The tester has also been used to examine the causes of fatigue in cotton tire cord. It is concluded that the failure is due to fiber damage, but the real cause of that damage has not been found. Fatigue in tire cord appears somewhat analogous to that in metal in that damage within the structure is much deeper than surface examination would indicate.

Steel tire fatigue is rather different from textile cord fatigue, and a tester is described for testing this material. It is shown that although work-hardening increases the tensile strength of the wire, the compression fatigue resistance is reduced.

53. **Pneumatic Tire Testing.** J. I. S. Williams and R. G. Clifton, Dunlop Rubber.

Few papers have appeared on this subject, although testing has been going on virtually since the first pneumatic tire was made. The present paper presents a broad review of the newer techniques involved in this work.

Reference is made to accelerated wear tests. Skidding tests, both on an outdoor track and an indoor ice surface, are reviewed, and work on captive vehicles for the study of the effects of body roar, tire out of balance, and other tire/vehicle features is discussed.

Considerable work has been done both on the road and on indoor machines to correlate temperature generation under various sets of conditions. The subject of drum-type testing out of doors is touched upon.

Purely indoor testing covers the long-established structural tests, measurements of cornering force and self-alining torque, rolling resistance under various tire conditions including torque transmission by the tire and tests at speeds up to over 400 m.p.h.

In the discussion on high-speed testing, reference is made to car and motorcycle racing tires and to aircraft tires. In connection with the latter an interesting piece of equipment is a machine powered by a Rolls Royce Merlin engine which will test two tires at a time and is capable of controlled landing and take-off sequences; it is possible to coordinate load application or removal with change of speed.

73. **A Quick, Easy Method for Determining State of Cure of Vulcanizates.** L. R. Sperberg, Sid Richardson Carbon Co., Odessa, Tex.

One of the foremost problems confronting the rubber technologist today is the lack of a suitable test for determining state of cure of vulcanizates. As a consequence, most comparisons of pigments or compounds are clouded by inadvertent variations in states of cure of the different compounds under consideration. This condition has resulted in great hardship to technologists engaged in research and development compounding.

Before one can measure, one must, of necessity, define vulcanization. The simplest definition of vulcanization is one that defines vulcanization in terms of the property which undergoes the greatest visual change as a result of vulcanization: namely, the plasticity of the vulcanizate. Vulcanization, then, is any treatment which will reduce the plasticity of vulcanizates without materially reducing the elasticity.

The relaxed compression-set test was developed on the basis of this definition. It is a modification of Method B of ASTM Designation D395. It is conducted simply by compressing a pellet 35%, holding it at this compression for two hours at 212° F., then allowing the specimen to relax for one hour at 212° F.

The relaxed compression-set test works for all types of vulcanizates—gum, pigmented, natural rubber, synthetic rubber, sulfur cures, non-sulfur cures, etc. The results are expressed numerically between 100 and 0, where 100 represents an uncured compound, and 0 represents a totally cured compound.

When temperature coefficients of vul-

canization are calculated from relaxed compression set data, the results are in agreement with published data calculated from other criteria.

The relaxed compression-set test offers a reliable basis for comparing physical properties of vulcanizates at equal states of cure; and, to one familiar with the test, a definite value of relaxed compression set is highly indicative of a specific state of cure.

SIXTH SESSION—JUNE 25
COMPOUNDING: THEORY AND PRACTICE

CHAIRMAN, D. PARKINSON
DEPUTY CHAIRMAN, M. HEYWOOD

5. **Nature of "Chemisorptive" Mechanisms in Rubber Reinforcement.** V. A. Garten and G. K. Sutherland, University of Melbourne, Australia.

The present state of research in the field of reinforcing rubber fillers is reviewed, and it is pointed out that although a strong school of thought still maintains that the strength of bonding depends mainly on van der Waals, forces and therefore on particle size, a number of observations indicates the presence of reactive sites and suggests the possibility of strong bonds of a chemical nature between filler and rubber matrix. The phenomenon of "carbon-gel" formation as foremost among these is discussed as lending fresh support to the idea of chemical bond formation. This effect, known to be most pronounced in the presence of an *unsaturated* matrix, is correlated with the mechanism of vulcanization as proceeding via *free radical intermediates*. It is suggested that the formation of chemical bonds between pigment and rubber constitutes an *integral part* of the chemical cross-link formation commenced on the rubber mill and completed by vulcanization. This hypothesis is corroborated by results obtained during studies on the reactivity of pigment surfaces toward simple inorganic and organic free radicals.

It is shown that active pigments react with free radicals with the formation of non-ionic bonds. Hydrophilic blacks have been prepared by the attachment of SO_4—, free radical ions to the filler surface. Similarly, electrochemically produced stearate free radicals have been reacted with the surface to form hydrophobic carbons. The "benzidine blue" free radical, being the mono-oxidation product of benzidine, easily reacted with less active pigments and thus provided a useful measure of activity. From the experiments with free radicals, the number of active sites for various fillers has been calculated and shown to cover a range of 0.01-3.1 per 100 sq. Å. Multifunctional polystyrene radicals, obtained in the presence of excess oxygen, yielded cross-linked networks with carbon blacks which resisted solvent extraction. These are considered to be complete analogues to carbon gel.

The statistical mechanics of the rubber network have been developed to include cross-link formation as caused by rubber-filler interaction. It is shown that the mechanical properties of a rubber-compound that are controlled solely by the network structure are directly proportional to σ/r, the ratio between the number of active sites per unit area and the particle radius. The effects of various fillers on photographic emulsions have been studied, and the complex results obtained suggest the interference of several mechanisms, whose nature is not fully understood. It is suggested that the "Russell effect" in general may be based on ionization of the atmosphere by electrons available on surfaces of certain solid materials, as indicated by experiments with free radical solutions.

10. **Lignin as a Compounding Ingredient for Natural Rubber.** Mrs. I. Sagajllo, London Advisory Committee for Rubber Research, London.

The preparation and properties of natural rubber-lignin coprecipitates have been investigated.

Coprecipitates differing from one another in minor respects are obtained by varying the type of lignin, the ratio of lignin to rubber, and the conditions of coagulation and of compounding. Rubber-lignin vulcanizates containing 28 volumes of lignin p.h.r. have high tensile and tear strength and high resilience. Inferior abrasion resistance, however, renders lignin unsuitable as a complete substitute for carbon black in a tire tread. Data presented demonstrate the possibility of replacing part of the carbon black in a tire tread by a considerably larger volume of lignin without serious loss of tensile or tear strength and with positive gain in resilience.

Besides coprecipitation with latex other methods of effectively incorporating lignin into rubber are described. Hydrated lignin, a freely flowing powder containing 35 to 60% of moisture, can be incorporated into rubber to give compounds showing a similar degree of reinforcement to coprecipitates from latex. Finely ground dry lignin, superficially hydrated by wetting with water, also exhibits reinforcing activity. Masterbatches of high lignin content capable of giving good reinforcement have been prepared from latex and lignin slurries.

The loss of reinforcing activity of lignin on drying is discussed, and the possibilities are considered of preparing lignin in a dry, yet strongly reinforcing form which could be incorporated into rubber by conventional compounding methods.

16. **The Mooney Viscosity of Carbon Black-Rubber Mixtures.** Merton L. Studebaker, Phillips Chemical Co., Akron.

The principal properties of carbon black which must be considered in the study of rubber mixtures containing carbon black are (1) particle size and the related property, (2) surface area, (3) hydrogen content, (4) oxygen content, and finally a property which is more difficult to evaluate, but which is related to (5) the tendency to agglomerate. This latter term is referred to in the trade as a "structure" factor, and it is usually determined from oil absorption measurements. We have considered unvulcanized rubber-carbon black mixtures to be analogous to mixtures of carbon black with other liquid media, for example, mineral oil. It has been demonstrated by Weltmann and Green that the "plastic viscosities" of concentrated suspensions obey a modified "Arrhenius equation." In this paper it is shown that unvulcanized rubber-carbon black mixtures obey a similar equation.

The rheological properties of concentrated suspensions are profoundly influenced by long-range London-van der Waals' forces. Some of the laboratory tests by which these forces are studied by colloid chemists are specific volume of a powdered solid under pressure, sedimentation volume, oil absorption, plasticity, etc. A correlation is demonstrated between data obtained by these tests and Mooney viscosity.

A general equation is presented relating the Mooney viscosity with the concentration of carbon black and oil absorption. This equation applies to all of the data which have been examined in natural rubber. In GR-S, another term, the oxygen content of the carbon black, must be included.

20. **Rubber Reinforcement by Resins Prepared in Latex.**[6] J. Van Alphen, Rubber Stichting.

Polycondensation resins can be formed in acidified latex stabilized with non-ionic or cationic stabilizers by adding the necessary ingredients to the latex.

The rubber is coagulated at the same time, and the product is neutralized, dried, and worked up like dry rubber. There are indications that the resin is chemically bound to the rubber.

Rubbers prepared in this way, containing up to 30% aniline-formaldehyde resin or melamine-formaldehyde resin, have properties comparable with those of carbon black compounds, except for their light color. With 40 to 50% resin the products are tough and leather-like, and with 50 to 60% resin they somewhat resemble flexible plastics.

The products with 20 to 30% resin have already been tested as sole and tire materials.

Not only natural, but also synthetic rubbers, are reinforced by the resins prepared in this way.

27. **Oil Extension of Natural Rubber.**[7] G. J. Van Amerongen and H. J. C. De Decker, Rubber Stichting.

Numerous investigations have been carried out on the oil-extension of GR-S; such an extension is of first-rate economic importance. As knowledge of the oil extension of natural rubber is limited, a study has been made of the technical possibilities of this subject, with special reference to tread compounds. This investigation was confined to ordinary dry-mixing methods.

It was found that the best procedure was first to prepare a slurry of the filler in the oil and then to add this slurry to the normal premasticated rubber on the mill or in the internal mixer. This method has the advantage of avoiding the dust normally associated with carbon black mixing.

Adding oil (Dutrex 55) to rubber decreases the tensile strength, modulus, and hardness of the vulcanizate considerably. In the case of carbon black compounds, however, this softening effect of oil can be largely counterbalanced by the addition of an extra amount of carbon black. It is shown that to a normal natural rubber tread compound at least 25 parts of oil can be added without much harm to the mechanical properties if a suitable amount of carbon black is used.

Variations in the type of oil do not change the general picture very much, although some oils are disadvantageous from the point of view of aging or compatibility. Extension of natural rubber with various types of bitumen along the lines mentioned above is shown to be less favorable than extension with oil, although compounds with interesting properties have been obtained.

Road tests have been carried out, using tires recapped with oil-extended natural rubber. These tests prove that the wear properties of compounds containing 25 parts of Dutrex to 100 parts of rubber and those of non-extended compounds with the same type of black can be nearly identical.

68. **The Role of Intermediate Level Carbon Blacks in Rubber.** I. Drogin, United Carbon Co., Inc., Charleston, W. Va.

Intermediate level carbon blacks are

[6] Communication No. 255, Rubber Stichting.
[7] Communication No. 256, Rubber Stichting.

those which have adequate reinforcement in addition to certain advantages, such as low volume cost, high loading capacity, rapid incorporation, easy mixing, fast processing, smooth fast trouble-free tubing, quick cure, accurate molding, good physical properties, high hot tensile, high resilience, lively compounds with low heat build-up, high resistance to cut and crack growth, good aging, good wear, and good electrical conductivity. In the arbitrary classification of carbon black types, the intermediate level blacks at the lower rung are the general-purpose furnace (GPF) types, e.g., Sterling V, Kosmos 35/Dixie 35, and the British made blacks Kosmos 45/Dixie 45 and Ukarb 127; whereas at the higher rung they include the intermediate super abrasion furnace (ISAF) type, e.g., Kosmos 70/Dixie 70, Statex 125, Vulcan 6, and Philblack I. Ranging between the general-purpose furnace (GPF) and the super abrasion furnace (SAF) types are the following intermediate level blacks; fine furnace (FF) type, e.g., Statex 1; fast extrusion furnace (FEF) type, e.g., Kosmos 50/Dixie 50, Sterling SO, Statex M, Continex FF, and Philblack A, likewise known as medium abrasion furnace (MAF).

Greater interest is now being evinced by the rubber industry in the intermediate-level carbon blacks owing to high speeds, high power demands, economic measures, and quality considerations. As a result, these blacks, when used either straight or in blends with other types of black, are at present finding applications in a variety of products, e.g., passenger and truck tire treads, tire body stocks, including carcass, breaker, cushion and under-tread compounds, Butyl inner tubes, mechanical extrusions complying with various durometer and tensile strength specifications, molded goods, belting insulations, wire jackets, and footwear, depending on the factory set-ups for handling and processing of the stocks, specification requirements, and service performances of the finished rubber article.

The salient features of intermediate-level carbon blacks are outlined in this paper, with special emphasis on the processing, reinforcement, and performances at high temperature. Comparisons are also made of the differences between each black and contiguous types. Recommendations for the applications for each intermediate type are given, and typical compounds are shown.

78. **The Role of Particle Diameter and Linkage Formation in Rubber Reinforcement.** A. F. Blanchard, Dunlop.

Fillers with little effect on abrasion resistance differ further from carbon blacks in having little or no tendency to introduce some form of strong-type linkage which could stiffen and strengthen the rubber at high extensions. Such linkages are here termed primary to distinguish them from secondary (weak-type) linkages, which have a range of lower strengths, as revealed by breakage with applied stress, and contribute little to reinforcement. The abrasion resistance for a given filler concentration is much improved even by remarkably small numbers of primary linkages if the particles are sufficiently small; and it is comparatively insensitive to the number of primary linkages in the quantities normally obtained with carbon blacks. For instance, a considerable degree of reinforcement is obtained with the partially graphitized black known as Graphon, although this black shows drastically reduced capacity to form linkages and little change in particle diameter. The large differences in the wear resistance of vulcanizates containing different grades of carbon black must therefore be attributed mainly to the particle diameter itself rather than to the linkages formed. Moreover, primary linkages, as reflected by stress-strain measurements, could not explain the effect of particle diameter on reinforcement because they are unrelated to particle diameter. For good wear resistance the particles probably need to have macro-molecular dimensions, though small.

To regard the effect of particle diameter in terms of the interfacial area linkage formation is inconsistent with the above conclusions. For a given dispersion and concentration to filler it is suggested that reinforcement is most likely to find proper expression in terms of the number of linkages per particle and the number of particles. This is expressed mathematically in a tentative, empirical form of equation designed to fit general conceptions and to correlate roughly the abrasion resistance with filler particle diameter and with primary linkages as reflected by stress-strain measurements. The equation implies that reinforcement increases with diminishing particle diameter until an optimum is reached and thereafter decreases to become negligible for particles of molecular dimensions.

86. **Interaction of Rubber and Fillers during Cold Milling.** W. F. Watson, BRPRA.

The softening of rubber on cold milling is the physical result of a degradative process in which rubber chains are ruptured by the applied deforming forces into free radicals. Although performed mainly for the incorporation of vulcanization ingredients and fillers, cold milling is thus a rubber processing operation inducing chemical reaction between rubber-free radicals and the additives.

Consideration of the structure of carbon black makes it apparent that this filler may act as a radical acceptor of a special polyfunctional type, i.e., a particle reacting with more than one-half of a sheared rubber chain. Further, rubber chains attached to a carbon black particle could also undergo scission by shear, and the fragments react with other particles. On this picture, one envisages a network of rubber and carbon black particles held together by chemical bonds. Although the structures of semi-reinforcing fillers and the new silicate fillers comparable in effect to carbon black are unknown, this approach to carbon black-rubber combination can be extended to them.

A network of combined filler particles and rubber would be insoluble in rubber solvents and form a swollen gel. The insolubilization of rubber and carbon black has been reported occasionally, though no convincing experiments have been designed for interpreting the phenomenon. The experimental part of this paper is concerned with systematic measurements of the rubber-carbon black gel formed during cold milling and with further tests of the above hypothesis. The findings are all consistent with such a chemical combination of rubber and the other reinforcing agents investigated, and no comparably simple alternative explanation is apparent.

The chemical combination of rubber and carbon black contributes to the long-standing problem of the association of rubber and reinforcing fillers. The extent to which the reinforceable properties are affected becomes an immediate question. It is found that the stress-strain properties are markedly affected by this combination of rubber and filler.

[8] *Trans. Inst. Rubber Ind.*, 27, 127 (1951).

Seventh Session—June 25
Miscellaneous Technology

Chairman, J. G. Mackay
Deputy Chairman, L. E. Masheter

31. **Abraded Filament Tire Cords.** E. R. Gardner, A. E. Herbert, and W. C. Wake, RABRM.

Following the RABRM work on the contribution of protruding fiber ends from spun staple yarn on the adhesion of rubber to fabric, an examination has been made of the effect of abrasion on the adhesion and fatigue resistance of rubber to cord. The adhesion was measured by means of the H-block test, and the same type of test piece was used in fatigue experiments. Many ways of abrading the cord were investigated, and the uniformity of the abrasion was assessed by a statistical technique based on sequential analysis.

The results show that static adhesion increases linearly with abrasion until an optimum is reached. The improvement under dynamic conditions is not so marked unless the cord is subjected to a dipping procedure. The combined effect of abrasion and dipping into a latex-casein mixture is greater than either treatment applied separately.

34. **The Effect of Heat Setting on the Physical Properties of "Terylene" Polyester Fiber.** D. N. Marvin and T. J. Meyrick, ICI.

Synthetic fibers are finding increasing use in the rubber industry in the manufacture of rubber composite articles which involve widely different service conditions and in which a variety of physical and chemical properties assume importance. The essential properties of "Terylene" polyester fiber in fabric and cord form for these applications are discussed in relation to other materials.

However, "Terylene" filament yarn, as manufactured, and consequently the fabric and corded structures made from it, shrink on exposure to elevated temperatures. In order that the finished dimensions of the end-product may be accurately defined and the physical properties of the fiber retained at the required level, it is necessary to stabilize by a process known as heat setting. Heat setting processes are discussed, and information is given to illustrate their significance and effect.

Owing to the low moisture absorption and good chemical resistance of "Terylene," difficulties have been encountered in adhering it to natural and synthetic rubbers. Experiments demonstrating the adhesion obtained between these materials, using both aqueous and solvent bonding systems, are described.

64. **Wave Phenomena in Tires at High Speed.** D. M. Turner, Avon India Rubber Co., Ltd., Glasgow, Scotland.

Much experimental evidence on the formation of waves at high speed in tires was published in a paper by Gardner and Worswick.[8] Following these results, a theory has been developed which explains all the available evidence qualitatively and much of it quantitatively.

The wave formation is shown to be initiated by the kinetic energy of the tread as it leaves the road surface on rotation of the tire. If the velocity of rotation of the tire exceeds a critical value, then this energy manifests itself in the form of a wave.

The wave formation produced is characterized by three properties, (a) the modes of vibration excited, (b) their respective wavelengths, and (c) their initial amplitudes. The theory shows how these

properties depend on the following conditions and basic factors: (1) speed of rotation of the tire, (2) load and inflation pressure, (3) dimensions of the tire, (4) construction of the tire, (5) casing shape, (6) tread contour and pattern, and (7) physical properties of the materials composing the tire.

The mathematical analysis proceeds to show how the energy of the wave travels in the tire at a certain velocity away from the point of separation of tread and road. This leads to an expression for the power consumption owing to the wave which agrees well with experimental results.

A thorough understanding of these phenomena is needed by the tire engineers to design the tires required by modern high-speed transport.

23. **Tread Wear and Fuel Consumption of Tires.**[9] H. C. J. De Decker, R. Houwink, and G. J. Van Amerongen, Rubber Stichting.

The factors, wear and fuel consumption, should be studied jointly whenever a comparison is made between different types of tire.

An experimental study of passenger tire treads along these lines was started. Other very important factors, like carcass life, could not yet be included here.

The purpose of the investigation was twofold: (a) to compare ordinary synthetic and ordinary natural rubber passenger tread compounds; (b) to evaluate the influence of variations in natural rubber compound composition on these factors.

It is clear that this program is very extensive. Only a beginning has been made. Two American passenger cars were used for systematic testing in standard wear tests. Fuel consumption measurements were carried out on one of these test cars during special runs in which the car was equipped with appropriate measuring apparatus.

All these tests were designed on the basis of mathematical statistics, and the results were evaluated accordingly.

[9] Communication No. 258, Rubber Stichting.

Rowzee Named To Head C.I.C.; Gorrie To Head Rubber Division

The Rubber Chemistry Division of the Chemical Institute of Canada held its annual conference at the Royal York Hotel, Toronto, Ont., June 23, as a part of the annual conference of the Institute, which ran from June 21 through June 23. Attendance at the Institute conference totaled 1,250, a new record.

New Officers and Directors Named

The new president of the Institute is E. Ralph Rowzee, vice president and general manager of the Canadian Government synthetic rubber facility, Polymer Corp., Ltd. Among the members of the council of the Institute will be Norman S. Grace, Dunlop Tire & Rubber Goods Co., Ltd.; R. J. Allen, Canadian Titanium Pigments; and C. L. Brittain, Gutta Percha & Rubber, Ltd.

F. R. Gorrie, Cabot Carbon of Canada, Ltd., was elected chairman of the Rubber Chemistry Division. His vice chairman will be G. J. Baxter, Firestone Tire & Rubber Co. of Canada, Ltd.; secretary-treasurer, O. R. Huggenberger, Dominion Rubber Co., Ltd.; and the executive committee of the Rubber Division consists of H. K. Cunliffe, Dominion Rubber; J. A. Carr, Dunlop; W. Gedye, Monsanto (Canada), Ltd.; and E. J. Gibbon, Canadian Industries, Ltd.

F. R. Gorrie

Rubber Division Program

Abstracts of the papers presented before the meeting of the Rubber Division appeared in our May issue, page 226. Some additional comment following their presentation, however, is desirable.

Kenneth W. Doak, United States Rubber Co., in speaking on **"Promoters for the Reaction of Carbon Black with Rubber,"** concluded that the heating of rubbers and carbon black together causes a predominant change of physical properties which is facilitated by the addition of certain chemical reagents called promoters. The reacton involves the chemical linking of rubber chains through the carbon black particles. The reactivity of the process is related to the degree of unsaturation of the polymer; t-nitroso diphenylamine was mentioned as being especially effective in Butyl rubber, and the reaction with the carbon black is essentially complete after 20 minutes at 375° F. in a Banbury mixer. Two compounds, cumeme hydroperoxide and t-butyl perbenzoate, are especially effective as promoters for the interaction of carbon black with natural rubber.

In Dr. Doak's view the promoter causes the generation of free radicals which ultimately results in the abstraction of alpha hydrogen atoms on the rubber. These radical centers on the rubber react with active sites on the carbon black, thus forming a chemical bond between the rubber and the carbon black.

M. A. Pollack, technical consultant, W. C. Hardesty Co., in a paper entitled, **"Low-Temperature Plasticizers,"** emphasized the importance of the viscosity index of a plasticizer in choosing one for good low-temperature behavior, that is, the higher the viscosity index, the lower the brittle temperature. A high index means relatively little viscosity change with temperature.

In discussing **"Kinetics and Cross-Linking Effect in Mercaptobenzothiazole Vulcanization,"** Irving Auerbach, Goodyear Tire & Rubber Co., was mainly concerned with the problem of reversion, that is, the breaking down of cross-links, once they have been formed in the process of mercaptobenzothiazole vulcanization. Zinc oxide prevents reversion or breaking down of the cross-links, but does not alter the rate of combination of sulfur. Zinc

E. Ralph Rowzee

mercaptide added directly to the rubber gives less reversion during the first stages of vulcanization. According to this speaker, the zinc oxide reacts with the mercaptobenzothiazole, and this compound is chiefly responsible for the reversion process.

N. G. Duke, B. F. Goodrich Chemical Co., discussed **"Carboxylic Nitrile Rubber—A New High Strength Elastomer."** Since the polymer has pendant carboxyl groups, the chains can be cross-linked by reacting during vulcanization with metal oxides, such as zinc oxide. Vulcanization can also be carried out by conventional means with sulfur, but with a loss in tensile strength, although there is an improvement in compression set.

The gum stocks, cured with zinc oxide, show tensile strengths higher than 10,000 psi., and still retain good elongation and medium Shore hardness. Abrasion resistance of the latex films is better than that of films from nitrile latex. At present this polymer is available only in the latex form of which two types, viz., Hycar 1571 and 1572, may be obtained.

E. B. Storey, Polymer Corp., in his paper, **"Ozone Resistance of Butyl Vulcanizates,"** described a rating formula which combined number of cracks and

depth of cracks as follows: rating equals the cubed root of $n_D \times D^3$, where D equals depth of crack, and n_D equals the number of cracks. Polymer unsaturation increased the rating (i.e., reduced resistance to ozone), and increased state of cure reduced the rating.

There was a sharp reduction in rating when the level of carbon black in the compound was increased from 30 to 40 parts. Other agents which gave improved resistance to cracking were mineral oil, Santoflex AW,[1] Ethyl Selenac,[2] and Methyl Selenac.[2] Butyl vulcanizates do not begin to show ozone cracks until they are stretched more than 25%; whereas the threshold for ozone cracks in natural rubber is between 7% and 8%.

In contrast to the previous paper, W. G. Mayes, Firestone Tire & Rubber Co., in discussing **"Influence of Various Weathering Factors in Ozone Cracking of Natural and Synthetic Rubbers,"** rated the effect of ozone upon various vulcanizates by measuring the depth of crack. Increasing ambient temperature increased the depth of ozone cracks for the three polymers tested—GR-S, natural rubber, and Butaprene.[3] The depth of cracking reached an optimum at 12% elongation for GR-S and natural rubber; whereas for Butaprene, increasing elongation increased the depth of crack.

Dr. Mayes showed that the addition of wax to natural rubber improved the resistance to ozone when the sample was subjected to static elongation as long as the temperature was below 30° C. Increased ozone concentration increased the depth of the crack.

Ralph Treat, Continental Carbon Co., discussed **"Carbon Black for the Rubber Industry."** This paper reviewed the development of channel and furnace blacks and predicted further improvement in the life of the tire due to developments in synthetic rubber and carbon blacks.

R. D. Stiehler, U. S. National Bureau of Standards, in his paper, **"Statistics—A Tool in Testing Rubber,"** demonstrated some of the applications of statistical techniques to the testing of rubber and indicated that contrary to popular opinion, statistical techniques reduced rather than increased the cost of testing.

Dr. Stiehler concluded by describing the tire tester being developed at NBS. This tester has a circumference of 1/60 of a mile, a diameter of 28 feet, and can test 18 tires at once.

Boston Group Announces Technology Course

The Boston Rubber Group has announced a course in Rubber Technology to be given this fall in cooperation with Northeastern University, Boston, Mass. The course will have George H. Hunt, Simplex Wire & Cable Co., as instructor. The cost will be $40 per student, including application fee, but exclusive of required texts. Degree credit of 2½ semester hours will be allowed.

The course is described as a practical study of compounding and processing of natural and synthetic rubbers. Common compounding ingredients, various elastomers, and basic processing techniques and equipment will be covered. Some attention will be given to test methods, quality control, etc.

The course is designed for beginning compounders, salesmen, purchasing agents, production supervisors, specification writers, university students, and others interested in broadening their knowledge of the rubber industry and its technology.

Inquiries regarding the Boston Group Rubber Technology course should be addressed to Alan W. Bryant, Binney & Smith, Inc., 803B Park Square Bldg., Boston 16, Mass.

Tlargi Has Fine Outing

Two hundred and thirty-five members and guests of The Los Angeles Rubber Group, Inc., enjoyed the annual outing of the organization at the Miramar Hotel, Santa Barbara, Calif., over the week-end of June 12 and 13. F. C. Johnston, Caram Mfg. Co., headed the committee which made this fine outing possible.

Sports events starting on the afternoon of June 12 included a baseball game, won by the suppliers to the industry for the first time in several years. Honors in the golf tournament were won as follows: low gross, Skip McMahon, Cardox Corp.; low net, J. Ritchey, Firestone Tire & Rubber Co., and Milt Churchill, Kirkhill Rubber Co.; longest drive, Joe Hoefle, Plastic & Rubber Products Co.; closest to pin, Bud Field, Products Research Co.; longest putt, Bert Toevs, Shell Chemical Co.; blind bogey, Arnie Paulk, Naugatuck Chemical division, United States Rubber Co.; blind hole, Clayton Anderson, Midland Rubber Corp., and Chet Freude, Arrowhead Rubber Co.

Winners of the other sports events included: darts, R. M. Kavish, American Mineral Spirits; ping pong, John Arensmeyer, Ratliff Rubber Co.; shuffle board, the team of Bob Bowen, Firestone, and Don Montgomery, Xylos Rubber Co., and the team of Bud Burson, H. M. Royal, Inc., and C. A. Sickles, Master Processing Corp.; tennis, the teams of W. B. Everett, U. S. Rubber, and Bernie Hodowski, and Milt Stotz, W. J. Voit Rubber Corp., and Jesse Steele, Anaconda Wire & Cable Co. The two teams winning honors in horseshoe pitching were Ed McCosh, Cardox Corp., and A. H. Federico, C. P. Hall Co., and L. C. Boller, Coast ProSeal & Mfg. Co., and Yates Van Patter, Caram. The winners of the bean guessing contest were Artie Favenza, Alan L. Grant & Co., and Harry Trechter, Harwick Standard Chemical Co. Winners in croquet were H. O. Keefer, California Rubber Products Co., and Joe Ludholtz.

Favors for all present were possible by virtue of the work of W. B. Everett and his prize committee.

Golf Featured at SORG Outing

The annual outing of the Southern Ohio Rubber Group, attended by approximately 125 members and guests, featured golf for the amusement of the turnout. Held on June 5 at the Inland Activities Centre, the gathering also participated in various other games while consuming both liquid and solid refreshments.

There were 54 participants in the golf tournament, the winner of which were reported as follows: low net for blind bogey with scores of 67, Howard Butler, R. Bush, and Harold Boose, all of Inland Mfg. Division, General Motors Corp.; low net for 69, Tom Mattingly and Jim Wall, of Inland, Bert Stangor, E. I. du Pont de Nemours & Co., Inc., and C. L. Zimmerman, of C. L. Zimmerman Co.; low net for 70, James Haren, Precision Rubber Products Corp., and C. Moorman, J. Bohanan, and F. Hovey, all of Inland; low gross, Mr. Wall, of Inland, with a 77, R. Sucher, of Witco Chemical Co., with 84, and Lou Keyes, of Dayton Rubber Co., with 84; low net, Robert Conner, of Dayton; and high gross, James Hoerbelt, of Dayton.

The games and the winners in each were: foot golf, John McCloskey, of Inland; horseshoes, Paul Ludy, of Thresher Paint & Varnish Division, and Frank Newton, of Dayton; shuffleboard, C. Wimmer, of Phillips Chemical Co., and D. Strack, of Inland; and basketball, Mr. Newton, of Dayton, and J. Holmes, of Schenectady Varnish Co.

In addition, 77 door prizes were distributed among the attending persons.

GR-S X-766—Oil Masterbatch with Vinyl Toluene

The designation GR-S X-766 has been assigned to an oil masterbatch in which the base polymer is a copolymer of butadiene and vinyl toluene, by the Office of Synthetic Rubber, Federal Facilities Corp., Washington 25, D. C. The material, identical with GR-S 1710 except that the vinyl toluene is used in place of styrene, is described as follows:

37.5 parts aromatic processing oil plus 100 parts base polymer; approximately 23.5% bound vinyl toluene; sugar-free iron activated; 50/50 rosin/fatty acid soap emulsified; 41° F. reaction temperature; 60% conversion; carbamate short-stopped; staining stabilizer; salt-acid coagulated; and Mooney of masterbatch, 45-65 ML-4 at 212° F.

One production run of X-766 is scheduled to permit interested customers to evaluate the masterbatch with an eye toward establishing vinyl toluene as a possible monomer in case of an emergency. Small quantities of a LTP GR-S containing butadiene and vinyl toluene (X-689) were produced a few years ago and were accepted as comparable to GR-S 101 (now GR-S 1500). Production of X-689 was limited that time, however, because of the limited availability of vinyl toluene, a situation which has since been alleviated.

Titanium Pigment Expansion

New facilities for the annual production of 36,000 tons of titanium dioxide are under construction at St. Louis, Mo., by National Lead Co., New York, N. Y. The added capacity follows expansions at the company's St. Louis and Sayreville, N. J., plants.

Heretofore the St. Louis plant has been restricted to the production of calcium-base titanium pigments. The new facilities are so designed as to permit production of either calcium-base or pure pigment, as required by demand. The expanded facilities which will add 300 employes to the plant staff, are expected to begin production in July, 1955, and be in full operation by the end of that year.

[1] Monsanto Chemical Co., Akron, O.
[2] R. T. Vanderbilt Co., New York, N. Y.
[3] Xylos Rubber Co., Akron.

NEWS of the MONTH

Washington Report and National News Summary

Rubber Producing Facilities Disposal Commission negotiations with the 35 prospective purchasers of government synthetic rubber plants are proceeding at a good pace, with the possibility of a few contracts being signed very soon. Unofficial estimates of who bid for what plants have been made.

The future of the 12-year-old natural rubber research program in Latin America seems to be assured, thanks to the efforts of Rep. Paul Shafer (R., Mich.). The Foreign Operations Administration has assured continuation of the program at almost its previous level, and Congress is now agreeable to legislation and funds to complete the program.

GR-S production and consumption will rise to between 40,000 and 50,000 tons in September and October, with oil-extended GR-S amounting to an increasing proportion of these monthly totals.

The FTC tire quantity limit discount rule suits by 20 tire companies will be consolidated into one suit and the case is expected to come to trial in November.

A new government synthetic rubber price schedule, effective July 1, increased the price of Butyl rubber to 23¢ a pound and increased the prices on some GR-S latices.

Negotiations were broken off, and a strike was called by the URWA at the plants of the Goodyear Tire & Rubber Co. on July 7. Negotiations were resumed on July 19. A wage increase offer of the company of 5¢ an hour was termed inadequate by the union.

Negotiations between the URWA and United States Rubber Co., The B. F. Goodrich Co., and Firestone Tire & Rubber Co., on a wage increase were continuing in late July.

Washington Report by Arthur J. Kraft

Disposal Commission Negotiations Proceeding; Some Contracts Expected Shortly

The Rubber Producing Facilities Disposal Commission is still in the early stages of negotiating with the 35 prospective purchasers of government-owned synthetic rubber facilities. Through much of June and into July, the Commission's executive director, Eugene Holland, met privately with individual bidders—one at a time—to review various data contained in the sealed bids submitted May 27.

For instance, each bid contained a price which the bidder proposed to pay for the facility named in his bid. Holland, in his subsequent discussions with the bidders, asked how the bidder arrived at this price. The bidders, according to Holland, have been extremely cooperative and helpful in answering freely this question and providing other information.

By late July nearly all of the 35 bidders had been in to talk with the Commission's chief of staff, some more than once. Serious negotiation, however, has scarcely begun. Nevertheless the Commission is hopeful of signing at least a couple of contracts soon; apparently several offers appear in little need of further negotiating. The deadline for closing negotiations is December 27.

There is some prospect that the Commission will make public the signing of contracts as they occur, releasing the name of the prospective purchaser and the facility he has agreed to buy. A complete list of the bids submitted will be included in the Commission's report to Congress at the end of January, but won't be made public before then.

Who Bid for What?

Although the Disposal Commission has not as yet indicated which company has bid for what facility, certain private individuals have made educated guesses in this connection. There were reports current also on other aspects of the bids, such as price. One bidder supposedly entered a very low bid for a copolymer plant. The significance of this action appears to be that at least one rubber company, aware that the bids are subject to negotiation, prefers the strategy of entering a token offer, initially.

The bids for the copolymer plants, almost all of which were entered by their present operators, generally were lower, price-wise, than the bids entered for the butadiene plants and the styrene facility, that is, lower when judged in comparison with the official plant valuation figures. It is understood that there was considerably less competition in the bidding for the copolymer plants than for the butadiene and styrene facilities.

It is generally expected that the May 27 bids will undergo some drastic changes in many cases during the negotiation period. Several firms which entered separate bids on the same facility may have in mind joining hands to buy the facility together. The initial price offers will be another major subject of negotiation, with the Commission doing its best to jack up prices to meet its own ideas of "full, fair value."

Private efforts to link bidders with particular facilities have failed to ascertain any bids for a few of the facilities, the Institute, W. Va., copolymer plant; the Kobuta, Pa., alcohol butadiene plant; and the Naugatuck, Conn., dodecyl mercaptan plant. The Commission has by no means lost hope, however, of disposing of these plants and has said as much to anxious West Virginia Congressmen who don't want to see the Institute plant permanently "mothballed."

Otherwise, the Commission has made public only the names of the 35 bidders and the fact that they submitted a total of 56 primary bids and 19 second-choice bids. Unofficial sources have come up with the pairings shown on p. 681, which account for nearly all the 56 primary bids.

Phillips Offering 25c GR-S

Another report current related to the possible selling price of GR-S, when and if the producing plants go over to private industry, is that Phillips Chemical Co., which bid for the Borger, Tex., copolymer and butadiene plants, has been seeking customers for GR-S and promising delivery at 25¢ a pound.

This GR-S price is 2¢ a pound higher than the present government selling price, but below the price generally expected of private producers.

Future Outlook for Latin American Rubber Research Program Better

The government's 12-year-old research program on Latin American natural rubber problems is assured of continuation for another year, and the outlook for the future is much brighter. The inter-agency conflict in Washington over who should run and finance the program this year was temporarily resolved in July in time to head off a planned liquidation which was already in progress.

The Foreign Operations Administration entered into agreements with the Department of Agriculture covering the 1955 fiscal year ending next June 30, under which FOA agreed to take over the field personnel from USDA; operate the Cocoanut Grove, Fla., quarantine station which supplies rubber tree "budwood" to Latin American and southeast Asia planters; and avail itself of USDA technical consultants in the management of this program.

Most USDA Technicians to Remain

The chief aim of the program is to develop a blight-resistant, high-yielding natural rubber tree for Latin America; this aim will be pursued through the current fiscal year on only a slightly curtailed basis. FOA has agreed to keep four of

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the six USDA technicians employed at the Costa Rican experiment stations, where the main effort in the cooperative regional research program has centered. The four USDA technicians will be augmented, as in the past, by two Costa Rican Government technicians, making a total staff of six for this year, as compared with eight last year. Also being kept on are the two USDA technicians in Guatemala and one in Haiti. FOA has assured the White House that these actions will be enough to provide for continued progress in developing high-yielding, blight-resistant varieties of rubber trees, although the progress may not be so rapid as in the past. It certainly marks a more hopeful prospect for the program than FOA's previous decision (now to be withdrawn) placing the two Costa Rican stations on "standby maintenance" in charge of a sole USDA technician. FOA has not yet decided whether to continue the USDA rubber research work in Puerto Rico.

Shafer Appeal and Results

The agreements to keep the Latin American rubber research program operating through the current fiscal year on a fairly strong basis came only after an appeal by Rep. Paul Shafer (R., Mich.) to President Eisenhower to cut to the root of the inter-agency conflict and save the program. Mr. Shafer wrote to the President on June 8. The arrangements subsequently worked out by USDA and FOA were confirmed in a reply to the Congressman on July 13 from President Assistant Gerald D. Morgan.

With this letter in hand, Shafer called into his office the same day representatives of the agencies involved. Besides reviewing the status of the program for this year, they also discussed prospects for a permanent, longer-term solution. It was reported later that there will be strong support in Congress should the Administration seek legislation and implementing funds to expand the Latin American rubber research program. Expansion probably will require taking the program out of FOA (which doesn't want it, anyway) and placing it under some other agency, such as USDA or the State Department.

Here's how Morgan, in his letter to Shafer, summarized the outlook for the Latin American rubber program this year:

"The FOA advises me that, under the arrangements that have been made for handling the rubber program, they feel confident that the accomplishments of the rubber research program will be preserved and that rubber development projects in cooperating countries should make even more rapid progress as an integral part of our program of agricultural cooperation.

"Under the somewhat reduced operations contemplated this year, FOA does not expect to be able to make the same rapid advancement in rubber research as has been made by the Department of Agriculture (USDA) in recent years. However, it is anticipated that some continued progress in the development of high-yielding, disease-resistant varieties should be possible, and that there will continue to be a sound basis for any expanded program that may be advisable in the future."

GR-S Use Trend Still Up; Profits Good

Ninety-day advance purchase orders placed in July indicate an October sales volume of 46,000 long tons of GR-S, the Federal Facilities Corp. announced last month. FFC previously had forecast September sales of 48,000 tons and August sales of 44,000 tons.

FFC also announced that it plans to produce 39,000 tons of GR-S in August, upping this figure to 40,500 tons for September and 42,200 tons for October. The government-held inventory of GR-S stood at 80,000 tons on June 30, the last date for which figures are available.

These figures include the oil used in oil-extended rubbers, but exclude the car-

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ESTIMATE OF SYNTHETIC RUBBER PLANT BIDS

Bidder	Plant Type	Location	Present Operator
American Chemical Corp. (Richfield Oil, Stauffer Chem.)	Styrene	Los Angeles, Calif.	(Dow Chemical)
Dow Chemical Co.			
Foster Grant Co.			
Hercules Powder Co.			
Heyden Chemical Corp.			
Koppers Co.			
Monsanto Chemical Co.			
National Lead Co.			
Montrose Chemical Co.			
Shell Chemical Corp.			
W. R. Grace & Co.			
American Synthetic Rubber Corp.	Copolymer	Louisville, Ky.	(Ky.Syn.Rub.Co.)
Copolymer Corp.		Baton Rouge, La.	(Copolymer)
Firestone Tire & Rubber Co.		Lake Charles, La.	(Firestone)
Firestone Tire & Rubber Co.		Akron, O.	(Firestone)
General Tire & Rubber Co.		Baytown, Tex.	(General)
Goodrich-Gulf Chemicals, Inc.		Port Neches, Tex.	(Goodrich)
Goodyear Synthetic Rubber Co.		Houston, Tex.	(Goodyear)
Goodyear Synthetic Rubber Co.		Akron, O.	(Goodyear)
Midland Rubber Corp.		Los Angeles	(Midland)
Minnesota Mining & Mfg. Co.			
Edwin W. Pauley			
Standard Oil Co. of Calif.			
Phillips Chemical Co.		Borger, Tex.	(Phillips)
United States Rubber Co.		Port Neches, Tex.	(U. S. Rubber)
		Naugatuck, Conn.	(U. S. Rubber)
Climax Molybdenum	Petro. Butadiene	Lake Charles, La.	(Cities Service)
Merck & Co.			
Petroleum Chemicals, Inc. (Cities Service & Continental Oil)			
Goodrich-Gulf Chemicals, Inc.		Port Neches	(Neches Butane)
Texas Co.			
Allied Chem. & Dye (Gen. Chem. Div.)			
Sinclair Refining Co.		Houston	(Sinclair)
W. R. Grace & Co.			
Food Machinery & Chemical Co.			
Allied Chem. & Dye (G. C. Div.)			
Copolymer Corp.		Baton Rouge	(Copolymer)
Humble Oil & Refining Co.		Baytown	(Humble)
Phillips Chemical Co.		Borger	(Phillips)
Standard Oil Co. of Calif.		El Segundo, Calif.	(Stand. Oil Cal.)
Shell Chemical Co.		Los Angeles	(Shell)
Esso Standard Oil Co.	Butyl	Baton Rouge	(Esso)
Humble Oil & Refining Co.		Baytown	(Humble)

NOTE: J. G. Milligan & Co., as well as several of the firms named above, entered bids to buy parts of the fleet of 450 tank cars.

Publicker Industries, Inc., proposed to lease the Louisville alcohol butadiene plant.

Great Southern Chemical Corp. entered a bid to buy butylene facilities installed by the government at the firm's Corpus Christi, Tex., refinery.

W. R. Grace & Co.'s bid covered either the Lake Charles or Houston butadiene plants.

Climax Molybdenum and Merck are reported to be in together to buy the Lake Charles butadiene plant.

Koppers Co. is also reported to have bid on the steam plant only of the alcohol-butadiene plant at Kobuta, Pa.

bon black used in carbon black masterbatches.

Calculated on a similar net-plus-oil basis, total GR-S sales in the 12-month period ended June 30, 1954, amounted to 492,000 tons; while production over the same stretch totaled 522,700 tons. Excluding oil brings these figures down to 458,400 and 487,000 tons, respectively.

A breakdown of actual sales for June, on a net-plus-oil basis, shows a total of 36,594 tons, including 25,136 tons of LTP GR-S. Black masterbatch sales were 4,934 tons; oil masterbatch, 11,141 tons; oil-black masterbatch, 2,029 tons—all on a gross content basis, including rubber, oil, and black. GR-S latex sales were 3,487 tons, and GR-I (Butyl) sales totaled 5,744 tons.

July production had been scheduled as follows: total GR-S, 35,000 tons; LTP GR-S, 25,000; black masterbatch, 4,100; oil masterbatch, 13,400; oil-black masterbatch, 3,000; GR-S latex, 3,100; GR-I (Butyl) 4,800.

Emphasis on Oil Extended GR-S

The increased output of oil-extended rubbers is testimony to the attractiveness of a high-quality, low-price commodity. For some time consumer demand for the oil masterbatches has been rising steadily. The government, faced with disposal of the synthetic rubber plants next year, wants to convert more of its necessary GR-S inventory into the lowest-cost rubber it can.

July output may fall short of the planned levels as a result of the strike at the Goodyear-operated Akron plant and a two-day "wildcat" stoppage at the U. S. Rubber-operated Naugatuck plant. Both plants are important latex producers.

Profits Good

The government's synthetic rubber program brought in a net profit of about $43 million in the year ended June 30, 1954, and is expected to net about $50 million in the current fiscal year, Laurence B. Robbins, FFC head, told the House Ways and Means Committee on July 18.

The record high profit was the $58 million earned in the fiscal year which ended June 30, 1953. Prior to the slump which hit synthetic rubber sales earlier this year, Mr. Robbins' predecessor—Kenton R. Cravens, of the Reconstruction Finance Corp.—had told the same House committee that he expected a profit of nearly $70 million in the fiscal year ending June 30, 1954.

Butyl and GR-S Latex Prices Raised

Price increases covering about one-fourth of the government's production of synthetic rubber went into effect June 30—a few hours before control of the rubber program was switched from Reconstruction Finance Corp. to the new Federal Facilities Corp. in the Treasury Department.

The price boosts included an increase of 1¢ a pound for Butyl (GR-I), bringing the new price to 23¢, on a par with straight GR-S; increases ranging from 1¢ to 4¢ a pound for some GR-S latices; and an increase of ¾¢ a pound in the selling prices of carbon black masterbatches and oil-carbon black masterbatches. The allowance of ½¢ for each bale of black or oil-black masterbatches shipped bareback was discontinued.

Rubber program officials said the price boosts were effected without consulting the Treasury Department, where sentiment for raising synthetic rubber prices was—and may yet be—strong. The action taken by RFC, just before the agency went into oblivion, left unchanged the prices of the major types of rubber sold, including the lower-priced oil-extended GR-S polymers, and other tire rubber.

FTC Tire Quantity Discount Limit Rule November Trial Likely

Attorneys for the Justice Department and the 20 companies which have brought separate suits against the proposed Federal Trade Commission Quantity Discount Limit rule on tires met in Washington, July 14, in an effort to consolidate all 20 suits for trial.

Almost all of the 20 firms are tire manufacturers, who would be directly affected should the quantity limit ruling be upheld by the federal courts. The Justice Department, which is fighting the suits on behalf of FTC, went into District Court here June 9 with a request for a trial date. The Court is expected to set down the case for a November trial, at which time the adversaries will review procedures to be followed in arguing the merits of the Q-L rule.

The Justice Department has pledged an all-out defense of this rule, which has been held in abeyance pending the outcome of litigation. Under the proposed regulation—the first of its kind—manufacturers' discounts on replacement tires and tubes would be restricted to the maximum granted on a single shipment of a 20,000-pound carload. This ruling would prohibit the granting of large discounts based on the dollar volume purchased by tire merchandisers.

Meanwhile, it was reported that FTC is putting the finishing touches to a final report on its investigation of "over-riding commission" agreements entered into by 23 oil companies and three rubber companies. According to FTC, the oil companies receive such commissions on all tires, batteries, and auto accessories bought by their franchised, independent service station dealers and jobbers from the rubber companies. The commissions, 7.5% on jobber purchases and 10% on dealer purchases, are intended to cover promotional and other services provided by the oil companies for these jobbers and dealers.

The FTC investigation is aimed at determining whether this practice is restricting competition—whether the freedom of the jobber and the dealer in choosing his supplier of TBA goods is curtailed by these agreements.

No More "Leather Insert" Footwear Imports

President Eisenhower last month signed into law H. R. 6465, plugging a loophole in the tariff laws through which a British firm had attempted to escape payment of the high import duty levied on rubber footwear. The British company, seeking to take over the low-priced rubber-soled, canvas footwear market formerly held here by the Czech firm, Bata Co., had hit upon the device of inserting a thin leather strip between the rubber plies of the shoe sole.

This entitled the company to bring th article into the American market at the lower import duty charged for leather footwear. The bill signed by the Presiden on July 8 makes clear that such footwea must take the higher import duty assigned to rubber footwear.

National News

URWA Strikes at Goodyear Plants on Wage Issue; Negotiations Continue with Others of Big Four

Wage talks between the United Rubber Workers of America, CIO, and Goodyear, which began on May 4 and continued with one recess until July 7, resulted in a strike at all the Goodyear plants, beginning July 8.

At the last moment before the strike the URWA turned down as inadequate a company offer of a 5¢-an-hour wage increase. It was reported that the union was seeking a 7½¢-an-hour wage increase plus an additional amount to correct inter- and intra-plant inequities.

Goodyear Company Statements

E. J. Thomas, Goodyear president, released a statement on July 10, in which he expressed regret "that thousands of our fellow workers are now out of work as we know the hardships this brings about. As a matter of fact, some of the recent lay-offs we have experienced—along with some short time which we have been working—have been of real concern to us, and the whole sales organization and every other part of the management team have been working hard to sell all the goods possible in a very competitive market to provide the maximum number of jobs."

Thomas then went on to explain how the negotiations with the union had been carried on in good spirit and had resulted in an offer raising wages 5¢ an hour.

"This amount of additional wages was equal to the wage settlement that had taken place within the last few days, without any strike, in the steel industry, in the electrical industry, and matches the 5¢ wage increase made in June in the automotive industry; so that we felt that Goodyear employes were being treated fully as fairly as anybody working in the major industries . . . ", he explained.

It was stated that the plants were shut down in an orderly manner; but it is with real regret that he sees this recent action and turn of events, Thomas added.

"We hope we can minimize as much as possible any loss of markets due to this interruption of work, but there will inevitably be some loss which will affect adversely the number of people on our payrolls.

"Of course, we stand ready at headquarters to reason this thing out with the union at any time," Thomas concluded.

Another statement was made on July 21 by Thomas in which he first called attention to the fact that factory employes in 10 Goodyear plants represented by the URWA have been without jobs and pay

since July 7 because they were called out on strike by their union representatives.

"When the hour of midnight on July 19 passed, and no strike was called in the plants of our competitor, the United States Rubber Co., it became quite clear that *our* employes had been discriminated against in the matter of income," Thomas continued.

"I do not know whether this situation results from a deliberate plan or from confused thinking. I should dislike to believe it really was planned that way. But regardless of the reasons back of this situation, I do have a duty to point out the basic facts to our own people."

Thomas went on to explain that on July 7, union representatives rejected the Goodyear company's offer of a wage increase of 5¢ an hour and then proceeded to shut down the Goodyear plants. He reiterated that this increase matched recent increases in the steel, electrical, and automotive industries, which had been accepted, and no strike therefore resulted in these industries.

"We of Goodyear management did not question the *right* of Goodyear union representatives to make the strike decision, although we did challenge the *wisdom* and *justice* of the decision," he said.

"On Monday, July 19, in New York City, company and union negotiators for the United States Rubber Co. came up to the deadline for the cancellation of *their* contract. The union representatives had been given discretionary authority to call a strike in United States Rubber plants. An offer of a 5¢ increase had been made by the company and, at deadline time, not accepted by the union. Thus, the way had been cleared for a strike at United States Rubber, just as it had been at Goodyear. The Goodyear union policy committee made the decision to strike at Goodyear. The United States Rubber policy committee would have to make the decision in the case of United States Rubber. *But—no strike was called at United States Rubber.*

"So, employes of United States Rubber are getting *their* pay, but you are not getting *yours* and that doesn't seem fair," Thomas concluded.

URWA Position

The URWA position after the Goodyear strike was called was reported to be that the 5¢-an-hour wage increase would fail to bring the total wage increases granted rubber workers since 1946 up to the level of total wage increases received by either auto workers or steel workers.

It was added that Goodyear profits in 1953 were at a record high, and that "wage inequalities" within the firm were greater than those found in the plants of any of its major competitors. The company's position in the negotiations was also described as "very arbitrary from the beginning."

Negotiations between Goodyear and the URWA were resumed on July 19.

Other Negotiations

Meanwhile negotiations on a wage increase were taking place between the URWA and U. S. Rubber, Goodrich, and Firestone.

The contract between the union and U. S. Rubber expired on July 19, as mentioned above, but no strike was called here, and the old contract was continued on a day-to-day basis while negotiations continued.

Contract expiration dates for the other two members of the Big Four were July 26 for Goodrich and August 11 for Firestone.

Other Industry News

Goodrich Claims Tubeless Tire Patent Infringement by U. S. Rubber

A suit charging infringement of tubeless tire patent rights was brought by The B. F. Goodrich Co., Akron, O., against United States Rubber Co., New York, N. Y. on June 30. Filed in a Federal Court at Baltimore, Md., the suit asked the court to enjoin U. S. Rubber from further infringement and to award damages for previous violations.

U. S. Rubber claims that there is "no merit" to the suit, contending that "tubeless tires had been developed and tested by several rubber companies and individuals many years prior to the date of the Goodrich patent." The defendant says that it had developed, tested, and found workable tubeless tires as long ago as 1934. The patent is, therefore, invalid, according to the firm.

Only one patent, covering a particular construction of tubeless tires, is involved in the current dispute, it is believed.

The tubeless tire was first announced in 1947 by Goodrich, which has since sold more than three million units. The company has offered to license tire manufacturers under its patents and to make available technical knowledge on the product. Patent rights were obtained in 1952.

Firestone Tire & Rubber Co. is also being sued on a similar charge by Goodrich; that action was brought last year in Cleveland, O.[1] The defense in that case, which is still pending, claimed that Firestone independently pursued its own development in the field of tubeless tires without appropriating anything covered by patents and that its products contain unique and superior features as compared to those manufactured by Goodrich.

Enjay Prepared to Market Butyl Rubber

Esso Standard Oil Co. has bid for the government-owned Butyl rubber plant at Baton Rouge, La., and, if successful in purchasing this plant, will market production through Enjay Co., Inc., Rockefeller Center, New York, N. Y., chemical marketing affiliate of Standard Oil Co. of N. J., according to O. V. Tracy, Enjay president.

To handle the servicing of Butyl rubber and Vistanex sales, a rubber division of Enjay is being formed under A. Bruce Boehm, vice president. Walter H. Peterson, who has long experience in the rubber field, is assisting Mr. Boehm in this work. Mr. Peterson has been associated with Enjay marketing activities for the past ten years. Prior to World War II he was with Haartz-Mason, Inc., and in 1942 joined the Synthetic Rubber Allocation Section, War Production Board, which section he headed later. He is presently on a parttime loan to the Office of Synthetic Rubber, Federal Facilities Corp., as a technical consultant on Butyl rubber.

Howard R. Moon, with The B. F. Goodrich Co., prior to joining Enjay in 1947, has also been assigned to the new division.

In support of the sales organization plans, M. W. Swaney, director of the Enjay laboratories division of Standard Oil Development Co., is preparing to give technical assistance on the use of Butyl rubber. Heading up the rubber section of Enjay laboratories is Harold J. Rose, assisted by J. L. Ernest, both of whom have extensive background in Butyl rubber technology. A new service laboratory is now under construction at the Research Center in Linden, N. J.

These men will be attending the meeting of the Division of Rubber Chemistry, A. C. S., at the Commodore Hotel in New York, September 15 through 17.

[1] See our June, 1953, issue, p. 374.

Du Pont Plans Industrial Products Research Lab

Plans for a research laboratory devoted exclusively to industrial products have been formulated by the textile fibers department of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Extensive work in the reinforced rubber goods field, including tires, belting, and hose, is scheduled for the initial facilities, with future plans for augmenting these facilities to be considered when needed.

To be known as the industrial products research laboratory, the unit will be located at Newport, Del., and will occupy approximately 15,000 square feet in the buildings which formerly housed the department's textile research facilities. Nearly $300,000 will be spent initially to renovate the site and install special equipment.

The new lab, staffed by some 40 persons, will develop additional industrial uses for du Pont fibers as well as establish research objectives for the development of new fibers. Limited research is to be conducted at the Chestnut Run textile research laboratory until the Newport location is ready, probably within a few months.

The company's textile fibers department also announced that its textile research division will become the textile and industrial products research division, with the new division to be headed by Howard W. Swank. Dr. Swank, a du Pont employe since 1937, was production manager of Dacron polyester fiber before this appointment.

John M. Swanson has been appointed research manager for the newly formed industrial products research group at Newport. Dr. Swanson was previously a supervisor in rayon research at Richmond, Va.

New Goodyear Airship Joins Fleet

The first production model of the Goodyear ZSG-4 non-rigid airship, an intermediate search craft, has joined the U. S. Navy's anti-submarine warfare team. The blimp, formerly designated the Goodyear ZP4K, was delivered by Goodyear Aircraft Corp. as the first of an undisclosed number of such ships to be built for the Navy.

The Goodyear ZSG-4 has a speed of about 65 knots an hour and can hover practically motionless or maintain low speeds. It has a capacity of 527,000 cubic feet of helium and is manned by a crew of eight.

Maiden flight of the prototype model was made in December of last year.

Goodrich Appoints Plastic Representative

Singleton & Mack, Inc., Marietta, O., has been named to represent The B. F. Goodrich plastic products department in the Central Midwest, an area described as including Ohio and parts of six other states. Coated fabric for office furniture, upholstery, and folding doors, calendered plastic sheeting and film, and rigid sheeting will be handled by the new representative.

Singleton & Mack was founded by two former Goodrich employes. President Norman P. Singleton joined the company in 1939 and was associated with the industrial products division as sales manager of calendered film for the Marietta plant before leaving the firm. Clarke A. Mack was with the same division of Goodrich as Mr. Singleton and held the post of flat belt sales manager when he left to become assistant to the president of Sun Rubber Co. in 1951. Mr. Mack recently left Sun Rubber to enter the new enterprise.

Shell Forms Resins Sales Group

Shell Chemical Corp., New York, N. Y., has announced the formation of a specialized sales group to expand the industrial application of Epon resins, a series of epoxy resins recently developed by Shell. The group includes R. L. Hallam, F. C. Herot, W. A. Hubbard, G. F. Metzinger, and D. M. Neely.

Epon resins, the company reports, are a new class of condensation polymers combining the properties of adhesion, chemical resistance, and flexibility to an unusual degree.

G-E Forms New Division

A chemical and metallurgical division, including the former chemical division and the carboloy department, has been formed by General Electric Co., Pittsfield, Mass. The former chemical division's four operating departments (plastics, Silicone products, chemical materials, and laminated and insulated products) will be joined by a fifth department, the carboloy department, under the new divisional set-up.

Robert L. Gibson, general manager of the chemical division, will be in the same position for the new organization. K. R. Beardslee will retain his post as general manager of the carboloy department, which was formerly the Carboloy Co.

Cabot Opens Wollastonite Mill

The opening and operation of a new $1,790,000 mill at Willsboro, N. Y., by Cabot Carbon Co., for the annual production of 60,000 tons of Wollastonite have been announced. Wollastonite, a pure, white, uniform calcium metasilicate, is currently used as a filler in the paint, ceramic, and plastics industries.

The new plant is modernly equipped for 100% mechanical handling and processing and can be easily expanded to meet increased production requirements. It was designed on the basis of experience acquired from an earlier mill, located about 1½ miles from the new unit, from pilot-plant experience, and from recent research.

American Dunlop Announces Expansion Plans

Dunlop Tire & Rubber Corp., Buffalo, N. Y., has announced that it plans to make a serious bid for a larger share of the passenger-car, truck, and bus tire market in the United States. The announcement was made at a press conference in New York, N. Y., July 24 by John H. Lord, executive director of Dunlop Rubber Co., Ltd., Fort Dunlop, England, and Glenn H. Crawford, president, Dunlop at Buffalo.

The firm has completely reorganized and has launched a three-prong program, involving new management, a $5-million modernization of manufacturing facilities at Buffalo, and means of increasing production by new industrial methods. Changes and improvements being made in every phase of Dunlop's production facilities at Buffalo will make possible a substantial increase in output and considerable savings in manufacturing costs, Mr. Crawford said. Among the new machines to be installed will be more than 30 Bag-O-Matic automatic tire curing presses made by McNeil Machine & Engineering Co., Akron, O. Improvements in materials handling are included in the modernization program which represents the start of a long-range project. About $3 million of the present expenditure will be spent on foam sponge facilities, and the remainder on tires.

At the same time, Mr. Lord revealed plans of the international Dunlop organization to build additional production facilities for the manufacture of foam sponge and tires at Whitby, Ont., Canada. He also reported that a new plant was placed in operation recently in Brazil and already is being expanded further.

Mr. Crawford, who has been president of Dunlop Tire & Rubber Corp. in Buffalo since April, 1954, heads the firm's new management team.

Goodrich to Purchase Sponge Rubber Products Co.

The forthcoming purchase of the assets and business of The Sponge Rubber Products Co. by The B. F. Goodrich Co., Akron, O., already approved by the directors of the former and to be submitted to the stockholders of that company in the near future, has been announced. Purchase will be by payment of Goodrich common stock.

It was also announced that the personnel of Sponge Rubber will remain the same. The added facilities and products of the Goodrich firm is expected to permit the company better to serve its customers as the Sponge Products Division of Goodrich.

Sponge Rubber Products Co., manufacturer of chemically blown cellular products of natural and synthetic rubber, latex, and plastics, operates plants in Shelton and Derby, Conn., Fall River, Mass., and has a Canadian subsidiary in Waterville, P. Q. The company was founded in 1923 by Frederick M. Daley, now president, and William R. Todd, now vice president and treasurer.

Pennsylvania Industrial Chemical Corp., Clairton, Pa., has appointed Rice & Co. as its representative to the protective coating and allied fields in the city of Cleveland, O.

American Hard Rubber In Reinforced Plastics

High-pressure compression and transfer molded parts of glass-reinforced plastics are now available from American Hard Rubber Co., New York, N. Y., to mark the firm's entry into this field.

The company expects that high-pressure molding will extend the application of this type of plastic to parts that have varying section thickness, complex details, and multiple inserts. Development work on glass-reinforced polyester resins to date has been primarily in the low-pressure preform and hand lay-up techniques, limiting the application of the material to relatively simple shapes with uniform section thickness.

The process, which requires the use of high-pressure compression presses of the type that the company now possesses, is based upon loading the mold or transfer pot with a measured charge of the resin-glass compound, applying pressure to form the material in the desired shape, and curing under heat and pressure. Cavity pressures in the order of 2,000 psi. are employed.

Rubber Panels as Part of Atom Sub's Hull

Sound transparent rubber panels will be part of the hull of the Navy's new nuclear-powered submarine, the *Nautilus,* when it takes to sea. The panels will provide a protective housing for the sonar electronic gear which uses sound waves to detect the presence of other ships and as an aid to navigation.

Both the bow and the stern of the undersea craft will be equipped with the panels, product of The B. F. Goodrich Co., Akron, O. Goodrich has been manufacturing sound transparent rubber since before World War II; the first application was as sonar domes for Naval craft. The recently developed panels, strong enough to withstand the pressures of underwater service, are expected to find application in commercial ships of the future.

C-S Building Ammonia Plant

Columbia-Southern Chemical Corp., Pittsburgh, Pa., has begun construction on a $3,000,000 ammonia producing facility at its Natrium, W. Va., installation. Operation of the new plant is expected by April, 1955.

The unit, which marks the entry of Columbia-Southern into this field, will utilize the hydrogen produced as a by-product of the electrolytic production of chlorine and caustic soda at other facilities on the site.

Marks Fiftieth Anniversary

The Stein-Davies Co., Long Island City manufacturers of dextrines and one of the industry's pioneers in this country, is rounding out its half-century of existence. The chief subsidiary of Stein, Hall & Co., the organization was founded in 1904 by two New York merchants, Leo Stein and Frnak G. Hall, who subsequently joined forces with Samuel D. Davies, a native of Scotland, where the dextrine industry originated.

Dinsmore Receives 40-Year Pin and Testimonial Dinner

R. P. Dinsmore, vice president in charge of research and development for The Goodyear Tire & Rubber Co., was awarded a 40-year service pin on July 6. The presentation was made by Chairman P. W. Litchfield at the Goodyear Theatre in Akron, O., before several hundred officials and employes of the Goodyear organization. President E. J. Thomas acted as chairman, and short addresses were made by R. S. Wilson, vice president in charge of sales, and H. L. Hyde, vice president and general counsel.

In the evening of the same day Dr. Dinsmore was honored with a testimonial dinner at Akron's Hotel Mayflower, attended by more than 500 members of the Goodyear organization and a large number of friends from various sections of the country.

President Thomas was toastmaster and displayed a rare gift of humor. The principal speaker was Webster Jones, vice president of industrial and government relations of the Carnegie Institute of Technology. He paid a glowing tribute to Dr. Dinsmore's long service with Goodyear and to his work for the benefit of the industry as a whole, particularly in synthetic rubber research, for which he was awarded the Colwyn Gold Medal, of the Institution of the Rubber Industry, in London, in 1947.

At dinner Dr. Dinsmore was presented with a very fine camera by his associates. He also received a specially prepared portfolio, including photographs and cartoons of his life and career, letters from many friends who were unable to attend, and the signatures of several hundred of his associates.

Dr. Dinsmore is a native of Tewksbury, Mass., and a graduate of Massachusetts Institute of Technology. He joined Goodyear in 1914 to work on technical service and compounding in Akron. Subsequent chemical assignments took him to Canada and Los Angeles. He was appointed to his present duties in 1943.

U. S. Rubber Co. Stockholders Increase in Number

Common stock ownership of United States Rubber Co., Rockefeller Center, New York 20, N. Y., has broadened by nearly one-half in the 2½ years since the company announced a 3-for-1 split of the stock.

On June 30 there were 24,399 common stockholders, a gain of 8,037, or 49.1%, over the 16,326 on record the end of '51.

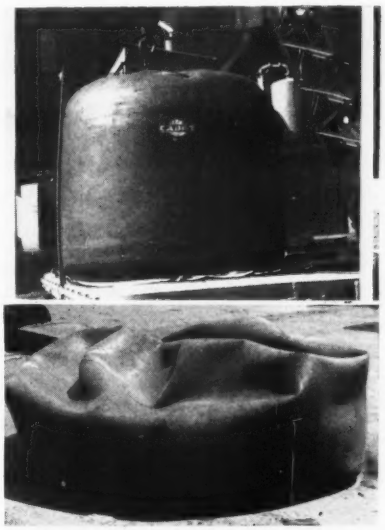
About one-tenth of this gain took place in the first six months of 1954, when 813 common share owners were added.

Preferred stockholders numbered 9,554 on June 30 (129 less than six months earlier), bringing to 33,953 the combined total of common and preferred stockholders.

Firestone Gets NSC Award

The Public Interest Award for "exceptional service" to public safety education through advertising during 1953 has been presented to Firestone Tire & Rubber Co., Akron, O., by the National Safety Council, Chicago, Ill. The company received the honor for its numerous safety promotion projects presented to radio and television audiences on the "Voice of Firestone."

R. P. Dinsmore *(Right)* Receiving His 40-Year Pin from P. W. Litchfield



New Five-Ton Rubber-Fabric Container for Shipping Carbon Black—(*Top*) Full; (*Bottom*) Collapsed

Five-Ton Package for Shipping Carbon Blacks

The Firestone Tire & Rubber Co., Akron, O., recently reported a successful test of transporting carbon blacks, from Godfrey L. Cabot Co., Cabot, La., to Akron, in a new five-ton package, constructed of rubber and fabric. This collapsible container is loaded at the top and can be emptied into a storage tank through valves and a canvas spout at the bottom. When filled, the package stands eight feet high and eight feet wide. Its empty weight is about 500 pounds.

This container will be used to transport those carbon blacks which are required in smaller than tank-car lots. It is readily adaptable to shipment by truck, barge, or rail. A 40-foot gondola freight car can be loaded with five full bags; a 40-foot box car will carry 43 collapsed bags.

Among the advantages mentioned for this container are: it will help improve plant cleanliness; it will reduce waste; and it will cut transportation costs.

Eagle-Picher to Buy Fabricon Products

An offer to purchase all of the capital stock of Fabricon Products, Inc., for $9,900,000 has been made by The Eagle-Picher Co., Cincinnati 1, O. Eagle has options to purchase 271,545 shares, or approximately 90.5%, at $33 per share, and is offering to purchase the remaining 28,455 shares at the same price.

Fabricon manufactures fiber products for the automotive industry; waxed paper and cellophane packaging materials; and plastics, including the impregnation of fabrics and papers and the molding of glass fiber reinforced polyester resins. The company operates six plants in River Rouge, Bridgeport, Philadelphia, Pittsburgh, and Los Angeles.

Fabricon has experienced substantial growth during the past decade, with sales rising from $6,668,000 in 1942 to $27,058,000 in 1953. The firm has no funded debt or preferred stock and has current assets of $7,216,000 and current liabilities of $2,559,000. Fabricon will operate as a division of Eagle-Picher under its present management, headed by President Louis A. Fisher.

Nygen Cord in Giant Tires by General Tire

The General Tire & Rubber Co., Akron, O., is now using Nygen fabric in the manufacture of all giant tires produced by the company. With this change to off-the-road and special-purpose tires, the company completes the cycle in making available Nygen-containing tires in truck, passenger, and giant units.

General first introduced the tire cord, manufactured by twisting nylon filament into cord and prestretching it under heat, in truck tires last year and followed with Nygen in the passenger-tire line at the start of this year. The present conversion from rayon fabric in the giant tires covers sizes ranging from 12.00x20 to 27.00x33.

The cord itself is said to be stronger than steel cable, when compared on a weight basis. This added strength is achieved by the prestretching operation, which also eliminates dangerous stretching when the fabric is incorporated into the tire. The company has invested millions of dollars in new production facilities at its Akron plant to manufacture the cord, including a new type of drying oven and a high-speed calender which can turn out 30 tons of Nygen daily.

Georgia Marble's Dent Promoted

John W. Dent, vice president and head of the calcium products division of Georgia Marble Co., Tate, Ga., has been elected executive vice president of the company. He is succeeded as head of the calcium division by T. J. Durrett, Jr., a vice president.

Under Mr. Dent's direction since 1947, the division has grown to be one of the major producers of high calcium marble dust for rubber filler application.

Mr. Durrett, a vice president for the past 10 years, has served the company during the past year as general supervisor of the Tennessee and Vermont quarries and plants. He has also held full responsibility for plant design and construction of the firm's five calcium products division mills at the two Georgia installations.

Zipper-Sealed Panels for Airplanes

Baggage compartments in Lockheed's new Super Constellation have rubber-glass fiber linings closed by pressure-sealing zippers developed by The B. F. Goodrich Co., Akron, O. Thirty-three zipper-closed panels in two baggage compartments are located in the lower section of the plane fuselage. The zipper features two overlapping rubber lips that seal tight against pressures over a wide temperature range. The panels and the seals allow for accessibility through quick-opening walls to meet all CAA safety requirements and to withstand the weight of shifting loads and the scuffing of moving cargo.

The zippers are also used in industrial and aircraft air duct systems, aileron gap seals, auto convertible top weatherseals, airtight and watertight carrying cases, and other applications.

Neoprene-Treated Paper for Auto Seat Covers

Neoprene latex, added as a wet-strength agent to the pulp of light twisting paper, is making possible the manufacture of fiber auto seat covers that can be sponged off and that are resistant to fraying and coming apart when wet. The synthetic rubber, used to the extent of 3% or less, is said to be well suited to this application because of its elastomeric properties.

The manufacturer of neoprene, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., has published data which substantiates its claims for the treated paper. These are recorded below:

	Tensile Strength, Psi.	
	Untreated	Treated
Dry	4.6	4.8
After 24 hours in water	0.7	2.1
Synthesized perspiration (acidic and basic)	negligible	2.0–2.2

25 Years without a Lost-Time Accident

A unique industrial safety record, a quarter of a century without a single time-losing injury, was achieved recently by the employes of E. I. du Pont de Nemours & Co.'s rubber laboratory at Deepwater Point, N. J. This is the longest injury-free span recorded to date by any unit of the company, current holder of two world safety records in plant operations and construction.

The "Citation for Distinguished Service to Safety," a National Safety Council award, and the du Pont Company's Board of Directors' Safety Award have been presented to the installation for the 3,200,000 man-hours worked without a lost-time accident. According to du Pont, this record shows that the laboratory's employes are 90 times safer on the job than the average American in his "away-from-work" time.

New Home of Lee-Tex Rubber Products, Gardena, Calif.

Pittsburgh Plate Glass to Buy Natural Products Refining Co.

An agreement under which the assets and the business of Natural Products Refining Co., Jersey City, N. J., will be absorbed by Pittsburgh Plate Glass Co., Pittsburgh, Pa., has been announced. Representatives of the glass firm are currently familiarizing themselves with the operations of Natural Products, producer of sodium dichromate and potassium chromate, and a plan for reorganizing the firm is being formulated.

Neville Warehouse Opened

Warehousing facilities at Mystic Warehouse & Distributing Co., Medford, Mass., have been established by Neville Chemical Co., Pittsburgh 25, Pa., to speed delivery of resins, plasticizing oils, and other chemicals to customers in the New England area. Orders for these materials can be placed with the company or through its representative, T. C. Ashley & Co., Boston, Mass.

Silicone Tubing in Aircraft

A lightweight, flexible tubing has been developed by Flexible Tubing Corp., Guilford, Conn., from General Electric's SE-100 silicone rubber, for use in the de-icing system of the new Grumman S2F-1 Sub-Killer airplane. Highly resistant to wide temperature and pressure changes and easy to handle and install, the tubing is installed in the wings to duct negative and positive pulsating air pressure to the leading edges for de-icing. Because of its properties, the silicone rubber compound gives tubing that requires practically no replacement for the life of the plane, which can operate under the severest weather conditions in all parts of the world, it is also claimed.

Lee-Tex Balloons to Occupy New Plant in California

Lee-Tex Rubber Products Corp. of California, 321 E. Jackson St., Los Angeles 12, Calif., according to President H. W. McConnell, this fall will move into its new $350,000 plant in Gardena, Calif. This building will cover 58,000 square feet and will include a continuous 300-foot production line and 17 separate departments capable of producing more than half a million toy balloons daily.

Besides executive offices, the structure will house headquarters for the sales staff and national sales representatives under Director of Sales Harry Sugerman. Also in the building will be a merchandise display room, research and technical laboratory, conference room, and cafeteria for the 150-200 employes required to handle normal production.

Lee-Tex, which was founded in 1947, manufactures toy balloons, including other dipped rubber inflatable toys. In 1949 the company acquired the rights for the patented Iller-Smith process of full-color, photographic reproduction on balloons, now marketed under the name, "Exquis-Art."

President McConnell, who has had 30 years' experience in the balloon industry, is joined in this expansion program by Secretary-Treasurer A. Magid.

Angier to Build Plant

Construction of a modern manufacturing plant and sales office in Huntington, Ind., has been begun by Angier Products, Inc., Cambridge, Mass. The rubber cement and adhesive products of the company should begin flowing from the unit by October.

A modern laboratory, headed by Western Division Sales Manager John J. Kerr, will also be included in this plant to help solve technical problems of customers.

Heavy demand for these products by industrial concerns in the Midwest was given as the reason for this move.

Acme Rubber Forms Plastics Division

The formation of a plastics division within the Acme Rubber Mfg. Co., division of Acme-Hamilton Mfg. Co., Trenton, N. J., and the appointment of Cornelius T. Morris as sales manager of the new plastics organization have been announced.

Mr. Morris was previously associated with Stroukoff Aircraft Corp., as director of public and industrial relations.

New Version of "Marsh Buggy"

A recent adaptation of the Gulf Oil Corp.'s famous "Marsh Buggy," developed in 1936 for use in searching for oil in swampland, is now being tested by the government for possible military service. The vehicle functions equally well over water, swamp, deep mire, and dry land, according to the inventors.

It rides six feet above ground on 10-foot-diameter tires built by Goodyear Tire & Rubber Co., Akron, O. These tires are four-ply all-nylon cord units (120-33½) which have no treads. They enable the Buggy to float on water, achieving traction by means of rubber-cleated chains which function similar to paddle wheels on a steamer. If one tire is punctured, it is kept fully inflated by a compressor which feeds air in through the hub. Even if all tires fail in water, the airtight hub drums would keep the vehicle afloat. The soft tires also permit passage of the Buggy over stumps and stones without puncture, and centrally pivoted axles enable either wheel to rise two feet above the other to accommodate such obstacles.

Twenty persons or a maximum of 4,000 pounds can be carried by the motorized vehicle over most terrain at speeds from ¼-30 mph. on land and six knots in water.

A trailer, for loads up to 2,000 pounds, has been made to accompany the Buggy if needed.

Silicone Rubber in New Packaging Unit

Silicone Rubber Packaging Unit with Polyethylene Liner

A seamless hand-folded packaging unit, made of corrugated cardboard and containing a polyethylene liner, has been designed for handling General Electric Co.'s silicone rubber products by Albany Corrugated Box Co., Cohoes, N. Y.

The container has sides made of five thicknesses of the board for stacking strength and does not require staples. Its inner liner of plastic seals out moisture, dirt, and other foreign substances, it is said.

Opening is quickly effected by splitting two tapes, and the contents can be placed directly in the mills at the fabricator's plant. If only part of the contents is used, the container can be thoroughly resealed in the plant and preserved for future use.

Goodrich Named Best Managed Rubber Company by AIM

The B. F. Goodrich Co., Akron, O., has been named the best managed company in the rubber products industry, according to a recent publication of the American Institute of Management. The publication, *Corporate Director,* in an article entitled, "The Investment Value of Management Excellence," listed 34 companies in various industries as being the best managed in their particular field.

Among those so named, in addition to Goodrich, were E. I. du Pont de Nemours & Co., Inc., in the chemicals and allied products field, Minnesota Mining & Mfg. Co. in the miscellaneous manufacturers field, and General Motors Corp. in the transportation equipment industry.

In each of the industries covered, individual firms were rated on the basis of 10 categories of management function. Those categories, said to reflect best the quality of management, were economic function, corporate structure, health of earnings growth, fairness to stockholders, research and development, directorate analysis, fiscal policies, production efficiency, sales vigor, and executive evaluation.

Also presented in the above article was a comparison of the stock market prices for the best managed company's stocks over a one-year period from May 19, 1953, to the same date one year later. The increase realized by such stocks were given as follows: Goodrich, 32%; du Pont, 27%; 3M, 52%; and GM, 12%.

It is interesting to note that the increase over this same period for the selected stocks used in computing the Dow-Jones averages was 13%.

Goodrich Operates Columbus Distribution Center

The largest distribution center of The B. F. Goodrich Co., Akron, O., encompassing 200,000 square feet of floor space, was opened recently in Columbus, O. The district offices of the company's tire and equipment and industrial products divisions, plus 750,000 tires of all types, conveyor and transmission belting, hose, and other products are to be housed in the one-story structure.

Located on a 10-acre tract at 3770 Indianola Ave., the center will make possible overnight delivery of orders to parts of Pennsylvania, Ohio, West Virginia, Indiana, and Michigan.

Martin Buys Frost Toy Co.

The assets of Frost Toy Co., Worcester, Mass., manufacturer of toy printing sets, has been purchased by Martin Rubber Co., Inc., Long Branch, N. J. The equipment of the purchased firm has already been transferred to Martin's plant at Long Branch.

Martin will continue the manufacture of the staple printing sets, deliveries of which are scheduled to begin this month. The company also plans to add several newly designed sets to the line within the near future.

General Enlarges Wabash Plant

A 50,000-square-foot addition to the Wabash, Ind., plant of The General Tire & Rubber Co. will be erected by September 1 to increase the manufacturing and warehousing area of that unit. The improvement will take the form of a new building and will cost an estimated $124,000.

Has Detroit Sales Office

Pennsylvania Industrial Chemical Corp., Clairton, Pa., has opened a Detroit, Mich., district sales office at 500 Griswold St. to service Ohio, Kentucky, Michigan, and part of Indiana.

Mathieson Chemical, Olin Industries Merge

The stockholders of Olin Industries, Inc., East Alton, Ill., and Mathieson Chemical Corp., New York, N. Y., have approved the merger of the two companies to form a new corporation, Olin Mathieson Chemical Corp. The new company will be a diversified processing and manufacturing enterprise, with total assets of about $500 million and sales of over that amount.

The exact date of the merger has not been announced as yet. When effected, the merger will bring together two companies which are approximately the same size. The new corporation, which does not contemplate any changes in basic operation, will have about 36,000 employes, 43 plants in 24 states of the country, and 16 plants in foreign countries.

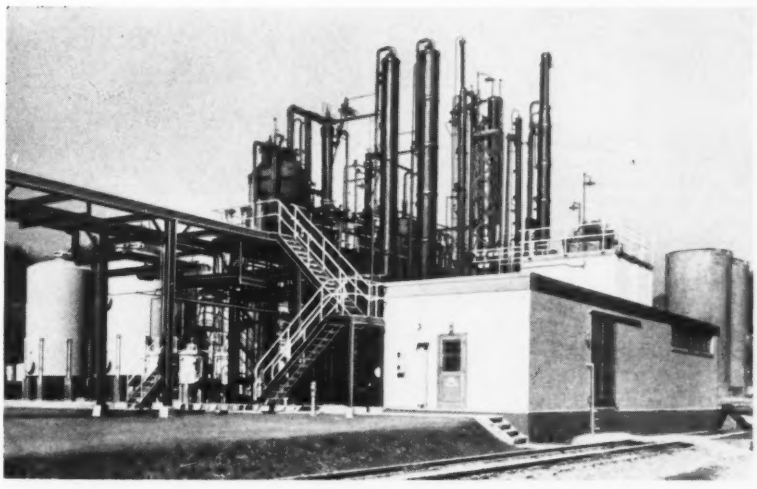
The stockholders also passed a restricted stock option plan for executives of the new firm, to be substituted for similar plans previously in effect in the two present organizations. Chairman of Olin Mathieson will be John M. Olin, now president of Olin Industries; while president of the new firm will be Thomas S. Nichols, now president and chairman of Mathieson. John W. Hanes, financial vice president of Olin, will become chairman of the finance committee of the new corporation.

GR-S Masterbatch from Private Firm

The first instance of private industry entering into the processing of GR-S latex into a dry masterbatch took place recently with the announcement by West Virginia Pulp & Paper Co., Charleston, S. C., of the commercial availability of a lignin-synthetic rubber coprecipitate.

Named Indulin-70-GR-S, the masterbatch uses Indulin, a pine wood lignin, as a reinforcing agent. The new material is produced by adding lignin as an alkaline solution to the latex and then coagulating with acid in the usual way. Production of the lignin by the company is as a coproduct of pulping wood for kraft paper and liner board.

For a description of Indulin-70-GR-S, see our New Materials column, page 710.



Commercial quantities of high purity grades ethyl and methyl acrylates are now being produced at this recently opened Institute, W. Va., plant of Carbide & Carbon Chemicals Co.

NEWS ABOUT PEOPLE

Richard K. Senn

Merrill T. Ham

Richard K. Senn and **Merrill T. Ham** have been appointed project engineers at Hale & Kulgren, Inc., Akron, O., and will specialize in new plant layouts and automation in connection with the firm's work of designing machinery and processes for rubber and plastics. Mr. Senn gained his business experience with Goodyear Tire & Rubber Co., National Rubber Machinery Co., and U. S. Army Ordnance; while Mr. Ham served with Monsanto Chemical Co., Hollingsworth & Whitney Co., and U. S. Army Engineers.

R. B. Bogardus, since 1929 assistant manager of crude rubber purchasing, Goodyear Tire & Rubber Co., Akron, O., last month received his 35-year pin denoting that much service with the company he had joined in 1919 as a member of the production squadron. He subsequently served in the crude rubber purchasing department; as warehouse manager of Goodyear Orient Co., Ltd., in Singapore (1922); office manager of the Dolok-Merangir plantations in Sumatra (1923); a rubber buyer at Singapore (1924); and assistant manager of the crude rubber division in Akron (1925). He was loaned to Rubber Reserve and Rubber Development Corp. during World War II and returned to Goodyear in 1946.

William D. Schaeffer, of Godfrey L. Cabot, Inc., Boston, Mass., was a guest lecturer at the Fourth Advanced Paint Refresher Course of North Dakota Agricultural College, Fargo, N. Dak., July 12-23. On July 15, Mr. Schaeffer lectured on "Controlling the Atmosphere of Carbon Black Surfaces."

J. G. Edmiston has been appointed technical sales representative for Monsanto Canada, Ltd., Montreal, P.Q., Canada. Mr. Edmiston, who has had wide experience in rubber chemicals as a technician and a purchasing agent, will be in charge of sales of Monsanto's products for the rubber industry in Canada. Monanto Canada is the Dominion affiliate of Monsanto Chemical Co., St. Louis, Mo., and manufactures a wide variety of accelerators, antioxidants, and other rubber chemicals.

Pach Bros., N. Y.

Eugene A. Luxenberger

Eugene A. Luxenberger has been elected vice president of the United States Rubber Co., New York, N. Y., and has been appointed general manager of its footwear and general products division. He is succeeded in his former position of assistant general manager of the division by **George T. Ward.** Mr. Luxenberger, who spent 33 years with U. S. Rubber, has also held the posts of factory manager of the Mishawaka, Ind., plant and assistant production manager of the division. Mr. Ward, general sales manager of the division from 1951 until this promotion, joined the company in 1925. He has managed two sales branches, the national branch sales organization, and general merchandise sales during his time with the firm.

O. E. Miles, former sales manager for the northcentral division of the Goodyear Tire & Rubber Co.'s retail stores division, has been appointed general manager of the newly reorganized retail stores organization.

Sales changes within the footwear and general products division of United States Rubber Co., Rockefeller Center, New York 20, N. Y., have been announced as follows: **R. H. Slate** has been appointed Pacific Coast sales manager; while **Jack L. Bruce** succeeds him as district sales manager of the Los Angeles branch; **Frank J. Yohan** has been named district sales manager of the New York branch; and **Joseph Anastasio** succeeds Mr. Yohan as district sales manager of the Buffalo branch. Mr. Slate, a member of the rubber company's sales organization since 1929, held managerial positions at the Denver and the Seattle branches before moving on to Los Angeles.

A. E. Cleghorn has been made executive vice president of National Aniline Division, Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y. He has been with the parent company since 1933 and with the Division since 1952, first as assistant to the president and then as vice president.

Pach Bros., N. Y.

George T. Ward

Philip W. Scott has been named to the newly created post of director of business development for Borg-Warner Corp., Chicago, Ill., and, as such, will also be on the research policy and planning committee of the corporation. Prior to joining Borg-Warner, Mr. Scott had been vice president and secretary-treasurer of Affiliated Gas Equipment, Inc.

G. Stafford Whitby, professor emeritus and director of rubber research at the University of Akron, Ohio, was awarded an Honorary Fellowship in The Chemical Institute of Canada at the annual conference of the Institute in Toronto, Ont., June 21-23. This honor was given in recognition of his significant contributions to Canadian chemistry and chemical engineering and his long participation and effective leadership in Canadian chemical organizations. Earlier this year, Dr. Whitby was selected as the 1954 Charles Goodyear Medalist of the Division of Rubber Chemistry, American Chemical Society, for his work on rubber research.

Andrew P. Ting and **Thorald C. Alexander** have joined the chemical research laboratories of Marbon Corp., Gary, Ind., manufacturer of high styrene resins and rubber-to-metal adhesives. Dr. Ting, who was educated in China, but who received his M.S. and Ph.D in chemical engineering in this country, will act as a group leader in the polymerization section of the development laboratory. He previously had been a chemical engineer in the process engineering department of Catalytic Construction Co.

Mr. Alexander, who will serve Marbon as a chemical engineer, comes from W. C. Hardesty Co., where he had acted in the same capacity from 1949 to 1954. Prior to that position he had been with General Chemical Co., following three years in the U. S. Marine Corps.

Robert W. Little has been appointed manager of the rubber chemicals division office of Hercules Powder Co., Akron, O., succeeding **Clifford S. Reppe,** who has been named assistant district sales manager of the company's paper makers chemical department, Holyoke, Mass. Dr. Little joined Hercules in 1948 and was assigned to the applications research division at the company's experiment station at Akron. In 1952 he became a member of the paper makers chemical department. For the past year and a half he has been connected with the rubber chemicals division of this department.

W. C. Schade is now executive vice president and general manager of Ball Bros. Co., Inc., Muncie, Ind., succeeding **Duncan C. Menzies,** who resigned about three months ago. Mr. Schade is in charge of all manufacturing and sales activities for both the parent company and Ball subsidiaries in six American cities. The 76-year-old Ball firm manufactures glass, metal, rubber, plastic, and paper products. Mr. Schade has gained his business experience with Olin Industries, Inc., Koppers Co., Brooks Paper Co., and a St. Louis firm of certified public accountants.

Charles F. Williams, Jr., and **James F. Driesch** have been added to the staff of Oakite Products, Inc., manufacturer of industrial cleaning and related materials, 19 Rector St., New York 6, N. Y., as technical service representatives. Mr. Williams, formerly plant manager of Regal Ice Cream Co., Denver, Colo., is representing Oakite in the new Sioux City, Iowa, territory; while Mr. Driesch, formerly Pittsburgh distributor for F & E Checkwriters, has taken on the Washington, D. C., area for Oakite.

Frank S. King has been named technical manager for tires at Dunlop Tire & Rubber Corp., Buffalo, N. Y. Coming from an 18-year tenure of employment at Firestone Tire & Rubber Co., Mr. King in his new capacity will have supervision of product development, technical service, and quality control of tire and tube manufacture.

Robert W. Ostermayer, since 1924 president of Pennsylvania Industrial Chemical Corp., Pittsburgh, Pa., was one of the recipients of the Distinguished Alumnus Award of The Pennsylvania State University, presented each year to five alumni whose personal life, professional achievements, and community service exemplify the objectives of the University.

United States Rubber Co., Rockefeller Center, New York 20, N. Y., last month announced the following changes in its U. S. tires division:

Walter F. Brown has been advanced to assistant sales manager of the division, with his headquarters at the company's general offices in New York.

J. A. Napier replaces Mr. Brown as north-central division manager. His former post, district manager at Pittsburgh, has been assumed by **J. S. Baker,** formerly assistant district manager there.

W. L. Anderson, previously division promotion manager at Chicago, is now district manager at Omaha, where he succeeded **D. A. Buchanan,** who will have a special assignment in the truck tire department.

John Tatum Cox, Jr., and **William Whitney Weinrich,** chemical engineers, recently announced their association as consultants, with offices at 1518 K St., N.W., Washington 5, D. C. Their work will cover rubber chemicals, petroleum, petro-chemicals, and atomic energy processes.

Three appointments to the sales service section of the chemical division of Goodyear Tire & Rubber Co., Akron, O., have been announced as follows: **Edward C. Brown, Jr.,** to provide technical assistance in the use and application of Plio-Tuf; **James F. Carraher,** to provide technical service to Pliovic resins customers; and **Earl Scott,** with 10 years of experience in research and development of coatings, to handle technical sales service on Chemigum, Pliolite, and Pliovic latices.

Marion T. Powers, field sales manager since 1944 of Kelly-Springfield Tire Co., Cumberland, Md., has been appointed vice president of that firm. Before joining the company, Mr. Powers was a sales executive of the Chrysler Division of Chrysler Corp., and prior to that assignment had been an assistant sales manager of Hudson Motor Car Co. and Wills St. Claire Motor Car Co.

Robert W. Richardson, vice president of Kelly-Springfield since early this year, has resigned to accept an assignment in the Goodyear Tire & Rubber Co.'s sales organization. Mr. Richardson joined Kelly in 1952 as assistant to the president, prior to which he had been with Goodyear since 1934.

Mr. & Mrs. Paul W. Litchfield Receiving Guests at Their Golden Wedding Anniversary on June 23

Verner Alexanderson has been named staff assistant to the technical director for intermediates and rubber chemicals at the Bound Brook, N. J., plant of American Cyanamid Co. He started with the company's plant at Linden, N. J., in 1939, was transferred to the New York offices as an engineer in the technical department in 1940, and five years later became a project engineer in the central engineering department. In 1951, Mr. Alexanderson was made a supervisor in the priorities and allocations department and the next year was assigned to Cyanamid's Washington office; but in 1953 he returned to the market research department as a senior market analyst.

C. Howard George and **L. S. Holstein** have been elected executive vice president and vice president, respectively, of The New Jersey Zinc Co., 160 Front St., New York 7, N. Y. Mr. George, a vice president for the past decade, has been with the company 39 years; while Mr. Holstein, for many years general manager of manufacturing and, since 1947, assistant to the president, began his service with N. J. Zinc, 42 years ago.

Harry Gerstin has been made vice president in charge of the Stafoam division of American Latex Products Corp., Hawthorne, Calif., which was founded in 1945 by C. M. Christie to manufacture, mostly, foam rubber cushioning. Later the company branched out into the manufacture of cellular rubber wing fillers, tank sealants, and gas-tank wrappings for aircraft. The company started production on Stafoam in 1950, and Mr. Gerstin has been instrumental in the growth of this division.

Richard T. Clark last month was appointed director of sales, raw materials, for the plastics division of Monsanto Chemical Co., St. Louis, Mo. Mr. Clark began with the company in 1939 in the sales department of the Merrimac Division, Everett, Mass., and then served in various sales positions in New York, Cleveland, and Boston. Since January, 1954, he was district manager of Monsanto's inorganic chemicals division sales headquarters in San Francisco.

V. H. Boden and **D. B. Mullin** have been appointed assistant sales managers of the industrial chemicals sales department of Carbide & Carbon Chemicals Co., division of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.

James A. Cruickshank has been appointed assistant sales manager of Naugatuck Chemicals, division of Dominion Rubber Co., Ltd., Montreal, P.Q., Canada. Mr. Cruickshank, who is a member of both the Chemical Institute of Canada and the Agricultural Institute of Canada, joined Naugatuck in 1946 as technical sales representative for Ontario and Quebec. Since 1951 he has been sales manager of agricultural chemicals, eastern division.

James Storey has been advanced to sales engineer for the Montreal, P.Q., Canada, district of B. F. Goodrich Chemical Co., Kitchener, Ont. He started with The B. F. Goodrich Rubber Co. of Canada, Ltd., in 1952 as a production trainee and later was transferred to the chemical sales division.

United States Rubber Co., 1230 Avenue of the Americas, New York 20, N. Y., in July made the following changes in its footwear and general products division:

C. W. Pennington was appointed general sales manager of consumers' products, responsible for sales of all waterproof and fabric footwear, waterproof clothing, foam rubber mattresses and pillows, sponge rubber rug underlays, golf balls, bathing caps, and other waterwear.

F. A. Sawyer was named general sales manager of manufacturers' products, including foam cushioning, automotive products, plastic upholstery and topping, Royalite plastic products, fuel cells, rubber shipping drums, Lastex yarn and rubber thread, and industrial sponge rubber products.

Louis J. Healey, who reports to Mr. Pennington, succeeded him as manager of branch sales and, as such, supervises sales of products through branch offices.

Arnold H. Finnern replaced Mr. Healey as assistant manager of branch sales. The former previously had served as Pacific Coast sales manager. In his present capacity he will also be responsible for the division's advertising, sales promotion, and public relations.

Fred Schott assumed Mr. Sawyer's former post of development manager. New assistant development manager is **E. C. Van Buskirk.**

Hewitt-Robins, Inc., Stamford, Conn., recently announced two promotions in its international division.

J. J. Murray has been appointed manager of foreign sales, with responsibility for the export marketing of products and services of domestic plants and foreign subsidiaries.

J. J. Sheehan has been made manager of foreign operations and will be responsible for general management policies and activities of foreign subsidiaries and affiliates, which are located in England, France, Canada, South Africa, and Italy.

Arthur P. Schulze recently joined Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, O., as manager of public relations and advertising, in both of which he has had several years' experience.

Oscar E. Kuhlman, who has been editing Diamond's Painesville plant employe publication for the past three years, has been promoted to assistant manager of public relations and advertising. He transfers to company headquarters in Cleveland.

Homer O. McCracken is now assistant factory manager of the mechanical goods division plant in Fort Wayne, Ind., of United States Rubber Co. Mr. McCracken, who started with the company in 1939 as a tire worker at the Indianapolis plant, served, successively, as a clerk in the tire control section; bookkeeper (1940); supervisor of general accounts (1941); group supervisor (1942); and, still within the tire control section, chief accountant and also administrative assistant (1944). In 1951 he went to company headquarters in New York and transferred to the mechanical goods division. His most recent post was factory coordinator for the division in the treasurer's department at U. S. Rubber's general offices in New York.

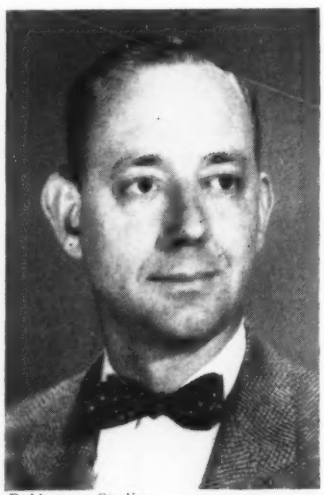
Edward J. Goett has been appointed director of the new commercial development department at Atlas Powder Co., Wilmington, Del.

Harold J. Klee

Harold J. Klee has been made manager of the newly organized central sales division of Stauffer Chemical Co., 380 Madison Ave., New York 17, N. Y. This division has district sales offices in Houston, Tex., and Chicago, Ill., where Mr. Klee will continue to make his headquarters. He is succeeded as manager of the Chicago sales district by the former assistant manager, **J. H. Begley.**

Richard J. Thompson has been named salesman—alkyd resin products sales—in the chemical materials department of General Electric Co., Schenectady, N. Y. He formerly was a technical sales representative for Trojan Powder Co.

Robert E. Munsell on July 1 became technical representative in New England for American Resinous Chemicals Corp., Peabody, Mass. For the past several years Mr. Munsell was in charge of technical development for the latex compounding department of Stein-Hall & Co., Inc., and prior to that connection had been a chemist in the research and development laboratories of The Flintkote Co. He is also a member of the American Chemical Society and its Division of Rubber Chemistry and of the New York Rubber Group.



Dahlmeyer Studios

Robert E. Munsell

Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y., last month announced the following promotions:

Edward W. Mathias and **Richard B. Miller** have been named treasurer and assistant secretary, respectively. Mr. Mathias had been assistant treasurer of the company for some time.

John F. Snyder, Jr., and **Herbert A. Rooney, Jr.,** have been appointed, respectively, superintendent and chief engineer of the company's new plastic molding compound manufacturing facilities at Kenton, O.

Harry A. Kleinert, Henry J. Fine, and **LeRoy Clayfield** have been elected directors of I. B. Kleinert Rubber Co., 485 Fifth Ave., New York 17, N. Y., in a move which increases the board membership from eight to ten.

Mr. Kleinert, who joined the company in 1927 and has been superintendent of its plant at College Point, L. I., since 1942, replaces his father, **Harry I. Kleinert,** on the directorate 28 years.

Mr. Fine, with the company 19 years, is production manager of the College Point plant.

Mr. Clayfield, who started with Kleinert in 1930, is its present merchandise manager.

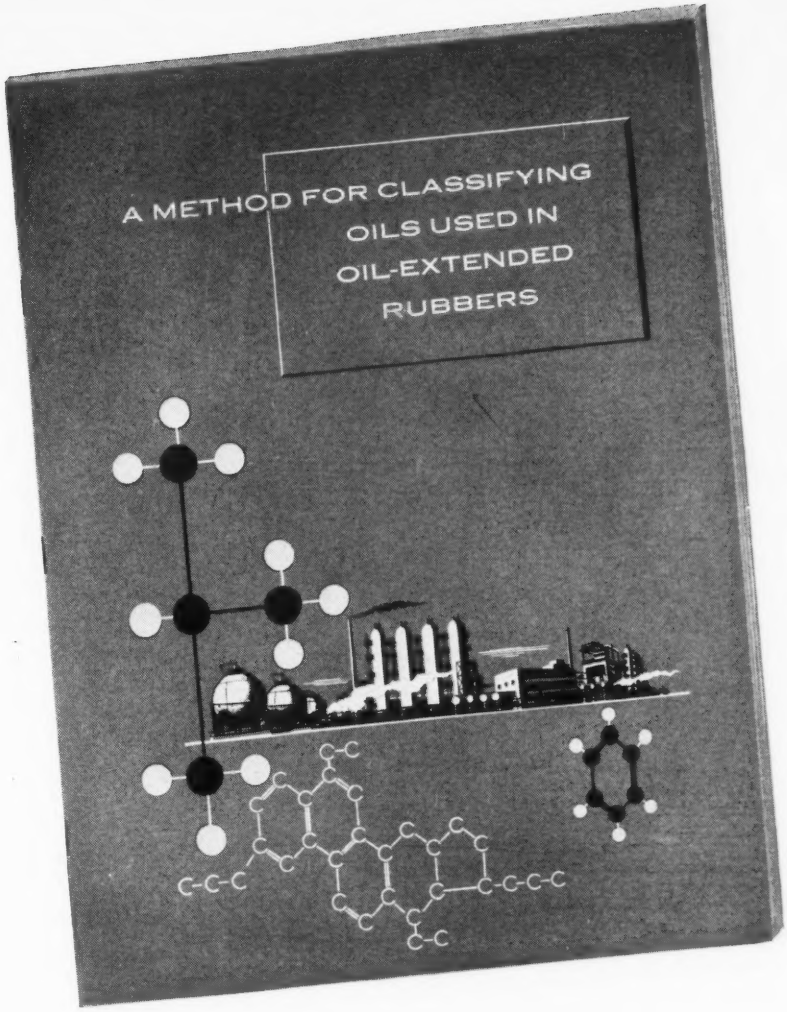
Richard M. Bleier, at the same board meeting, was elected a vice president of the company. He formerly had been assistant to President Ralph K. Guinzburg. Mr. Bleier is also a director of the company.

Roland H. Guinzburg was made executive vice president of the company, where he had started in 1911 as a chemist. Mr. Guinzburg, who is now in charge of both domestic and foreign production, has been a director of the company since 1926 and a vice president since 1932. Among his responsibilities are the factory in Canada and two new factories in England.

Emory M. Fanning has been put in charge of the new organic chemicals department sales training section at E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. His former post of assistant sales director of the "Kinetic" chemicals division goes to **William A. Bours, III,** who, in turn, is succeeded as chemical sales manager of the dyes and chemicals division by **Francis L. Shackelford, Jr.,** for the past year assistant sales development manager for the rubber chemicals division.

T. V. Hause is now representing Oakite Products, Inc., 19 Rector St., New York 6, N. Y., manufacturer of industrial cleaning and related materials, in Hartford, Conn., after having completed a training course at company headquarters and in the field.

Augustus B. Kinzel has been named director of research at Union Carbide & Carbon Corp., 30 E. 42nd St., New York 7, N. Y. Dr. Kinzel, who has been engaged in research with the company since he joined a subsidiary in 1926, will be responsible for the administration and coordination of the research activities of all divisions of Union Carbide, which are conducted in seven major laboratories, operated by the various divisions of the corporation, in South Charleston and Institute, W. Va.; Niagara Falls and Tonawanda, N. Y.; Bloomfield, N. J.; Cleveland, O.; and Indianapolis, Ind.



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Vincent Madsen has been appointed deputy managing director of the plantation division of United States Rubber Co., Rockefeller Center, New York 20, N. Y. Mr. Madsen will continue to serve as general manager of Malayan American Plantations, Ltd., and Hollandsch-Amerikaansche Plantage, Mij., wholly owned subsidiaries of the rubber company located in Malaya and Sumatra, respectively. He joined the firm in 1937, spent most of the past 15 years in that part of the world, including 3½ years as a Japanese prisoner, and became general manager of Malayan American Plantations in 1949 and of the Sumatra organization in 1952.

E. K. Stevens, vice president and treasurer of International Exposition Co., 480 Lexington Ave., New York 17, N. Y., has been elected president to succeed the late Charles F. Roth, with whom he was associated for some 20 years. Mr. Stevens, a mechanical engineer, also becomes manager of the National Exposition of Power & Mechanical Engineering, International Heating & Ventilating Exposition, and the Exposition of Chemical Industries.

W. D. Morrison has been named assistant to the director of the development department of Celanese Corp. of America, New York, N. Y. He was formerly assistant manager of the product development department of the company's chemical division.

William M. MacMillan has been named manager of sales promotion and advertising for the textile division, United States Rubber Co., Rockefeller Center, New York 20, N. Y. He previously had been with Deering Milliken & Co., Inc., in advertising and sales promotion.

Rogers Corp., producer of chemical-and-fiber specialty materials and impact phenolics, is now located in Rogers, Conn., a town formerly known as Goodyear, but recently changed to Rogers.

FINANCIAL

Monsanto Chemical Co., St. Louis, Mo., and consolidated subsidiaries. Six months to June 30, 1954: net profit, $11,434,961, equal to $2.12 each on 5,270,051 common shares, compared with $13,503,974, or $2.51 a share, in the 1953 half; net sales, $170,109,549, against $175,044,261.

Sidney Blumenthal & Co., Inc., New York, N. Y. June half, 1954: net loss, $526,471, contrasted with net profit of $169,830, equal to 47¢ a share, in the first half last year.

Crown Cork & Seal Co., Inc., Baltimore, Md. First six months, 1954: net profit, $739,516, equal to 61¢ each on 1,207,790 common shares, contrasted with $172,707, or 14¢ a share, a year earlier; net sales, $58,355,491, against $49,607,008.

Diamond Alkali Co., Cleveland, O., and subsidiaries. First half, 1954: net earnings, $3,115,753, equal to $1.26 each on 2,264,923 common shares, against $3,140,566, or $1.27 a share, in the 1953 half; net sales, $47,059,190, compared with $43,439,558.

Eagle-Picher Co., Cincinnati, O. Six months ended May 31, 1954: net income, $609,188, equal to 62¢ a common share, contrasted with $1,787,107, or $1.81 a share, in last year's period.

Endicott Johnson Corp., Endicott, N. Y., and subsidiaries. First six months, 1954: net profit, $945,799, equal to 99¢ each on 810,720 common shares, compared with $1,482,588, or $1.65 a share, in the corresponding period of 1953; net sales, $61,995,684, against $68,965,317.

Firestone Tire & Rubber Co., Akron, O., and subsidiaries. Six months ended April 30, 1954: net earnings, $18,129,727, equal to $4.52 each on 3,965,987 common shares, compared with $21,111,726, or $5.32 each on 3,928,877 shares in the 1953 period; net sales, $447,949,183, compared with $487,879,427.

The General Tire & Rubber Co., Akron, O., and subsidiaries. Six months to May 31, 1954: net income, $3,297,747, equal to $2.45 each on 1,207,321 common shares, compared with $3,482,750, or $2.73 each on 1,205,953 shares, a year earlier: net sales, $96,619,965, against $95,925,457.

General Electric Co., Schenectady, N. Y. First six months, 1954: consolidated net profit, $93,856,000, equal to $1.08 a common share, compared with $75,417,000, or 87¢ a share, in the 1953 half; sales, $1,447,597,000, against $1,560,448,000.

Johns-Manville Corp., New York, N. Y., and subsidiaries. Initial half, 1954: net profit, $8,028,069, equal to $2.53 each on 3,173,000 common shares, compared with $11,356,849, or $3.58 each on 3,168,851 shares, in last year's half; sales, $116,728,773, against $123,448,405.

Dividends Declared

Company	Stock	Rate	Payable	Stock of Record
Detroit Gasket & Mfg. Co.	Com.	$0.25 q.	Aug. 2	July 19
Firestone Tire & Rubber Co.	Com.	0.75 q.	Aug. 2	July 19
	4½% Pfd.	1.12½ q.	Sept 1	Aug. 13
Goodall-Sanford, Inc.	4% Pfd.	1.00 q.	Sept. 1	Aug. 16
Goodyear Tire & Rubber Co.	Com.	0.75 q.	Sept. 15	Aug. 16
	Pfd.	1.25 q.	Sept. 15	Aug. 16
I. B. Kleinert Rubber Co.	Com.	0.25 q.	Sept. 10	Aug. 25
Byron Jackson Co.	Com.	0.37½	Sept. 16	Aug. 30
Lee Rubber & Tire Corp.	Com.	0.75 q.	Sept. 2	Aug. 15
Mansfield Tire & Rubber Co.	Com.	0.25 q.	July 20	July 9
Thermoid Co.	$2.50 Pfd.	0.62½ q.	Aug. 2	July 12

OBITUARY

Charles F. Roth

Charles Ferdinand Roth, president of the International Exposition Co., New York, N. Y., and manager of the National Exposition of Power & Mechanical Engineering and Exposition of Chemical Industries, on June 24 succumbed to injuries received in an automobile accident.

The deceased was born in New York on December 24, 1886. He was graduated from Cooper Union in 1912, with a degree in chemistry.

In 1915, while chief chemist for Standard Oil Co. of New York, Mr. Roth organized the Chemical Exposition as an aid in relieving the strategic material shortages of World War I. During the same period he served as consulting chemist for International Filtration Corp. and as a director of Beckman & Linden Engineering Corp. In a career of 40 years he organized and managed more than 60 industrial expositions.

Mr. Roth belonged to many organizations including American Chemical Society, Chemists Club of New York, American Institute of Chemists, and Salesman's Association of the American Chemical Industry.

He also won several awards for his work in chemistry, including the Cooper Medal.

He leaves his wife, a grandson and a sister.

August J. Scheffler

August J. Scheffler, 77, president of Utility Mfg. Co., Cudahy, Wis., manufacturer of machinery for the rubber industry, died on June 26 while visiting a daughter in Phoenix, Ariz.

He was one of the founders of Utility in 1915 and was responsible for many of the developments in the company line of tire bead flipping machines as well as rubber cutters.

The deceased belonged to the McGrath Post of the Spanish American War Veterans and to various Masonic bodies.

Survivors include the widow, two sons, and two daughters.

Burial took place in Forest Home Cemetery, Milwaukee, Wis., last month.

Charles S. Davis

While on a European trip with his wife, Charles S. Davis, chairman of the board and former president of Borg-Warner Corp., Chicago, Ill., died in Paris, France, on July 2, at the age of 77. Funeral services were held July 16 at the First Baptist Church, Muncie, Ind., followed by entombment in the family mausoleum in Beech Grove Cemetery, Muncie.

Other survivors include two sons and a daughter.

Mrs. H. S. Firestone, Sr.

Mrs. Idabelle Smith Firestone, widow of Harvey S. Firestone, Sr., founder of the Firestone Tire & Rubber Co., died at her home in Akron, O., on July 7, in her eightieth year.

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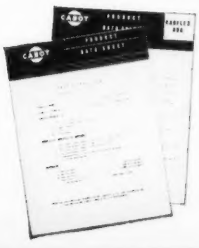
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NEWS FROM ABROAD

MALAYA

Smallholders Replanting Slowed

Problems multiply and become more complex as the Rubber Replanting Scheme for smallholders gets under way, the report of the Chief Replanting Officer, A. C. Smith, to the Rubber Industry (Replanting) Board, discloses.

It is no small task that has been set—to get almost 125,000 smallholders to replant 500,000 acres in seven years.

Under the scheme the smallholder gets $400 (Straits) per replanted acre from the government. The efficient handling of the considerable funds involved and inspection on the numerous plantings will require increasingly large staffs, and the main problem will be to get a qualified senior staff to guide and control operations.

Increasing difficulties in persuading smallholders to replant are also expected, as it is sought to widen the application of the scheme in successive years; already more and more smallholders are showing themselves averse to cutting down their old trees and replanting. The grant of $400 per acre, which in some districts has apparently been considered inducement enough to replant even a larger area than paid for, in many other instances is proving inadequate: it covers costs of replanting, but leaves little or no income to replace that lost by felling the old trees.

Many smallholders have been agitating for higher grants—$800 per acre has been suggested. It is understood that a sub-committee of smallholder representatives and a representative of the Member of Economic Affairs has been formed which is to report to the Board on the situation.

Mr. Smith also found that emergency rulings hamper efforts to make the scheme a success. While he intimated that indications were that the scheme probably would work to general satisfaction, he did foresee the possibility that it might prove necessary to cajole or force smallholders into replanting.

In 1953, just under 20,000 acres were replanted, and the target for 1959 is 500,000 acres.

The Rubber Fact-Finding Mission Starts Work

The three-man rubber fact-finding mission which arrived in Malaya in June consists of Sir Francis Mudie, chairman; J. R. Raeburn, reader in agricultural economics at the University of London; and Bernard Marsh, member of a leading firm of chartered accountants in London. The mission is expected to complete its survey in two months. In his first press conference in Kuala Lumpur, Sir Francis asked for information and opinions from all concerned, also from trade unions. He made it clear, however, that the mission could make no recommendations regarding wages, but that the prevention of unemployment would be considered.

Sir Francis is on the side of those who seek the salvation of natural rubber in replanting, stating that the industry must replant or die. He foresees keener competition from synthetic, with its production being taken up also by Germany, France, Italy, and Britain. He emphasized that with synthetic rubber production it is possible to put a new discovery to use within a year, thereby reducing its price in that time, but such is not the case with natural rubber.

Tappers Get New Wage Scale

Employers and workers of the rubber industry in June signed a new wage agreement which gives workers 10-15 cents a day more than the Taylor award, which it replaces, and at the same time guarantees a minimum of $2 a day to the lowest paid workers.

The new rates, which apply when the price of rubber is between 60 and 70 cents per pound, are $2.65 for contract tappers for a normal task, $2.40 for checkroll tappers, and $2.05 for field workers. (All Straits currency.) A cost of living allowance of 80 cents, effective while the cost of living indices are between 105 and 125 points, is included for all workers.

When the price of rubber is between 50 and 60 cents a pound, the daily rates (again including the 80-cent cost of living allowance) are $2.55, $2.25, and $2, for the three categories, respectively.

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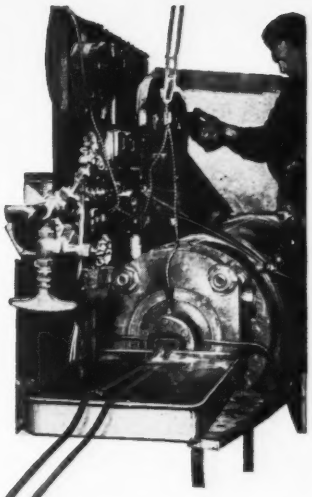

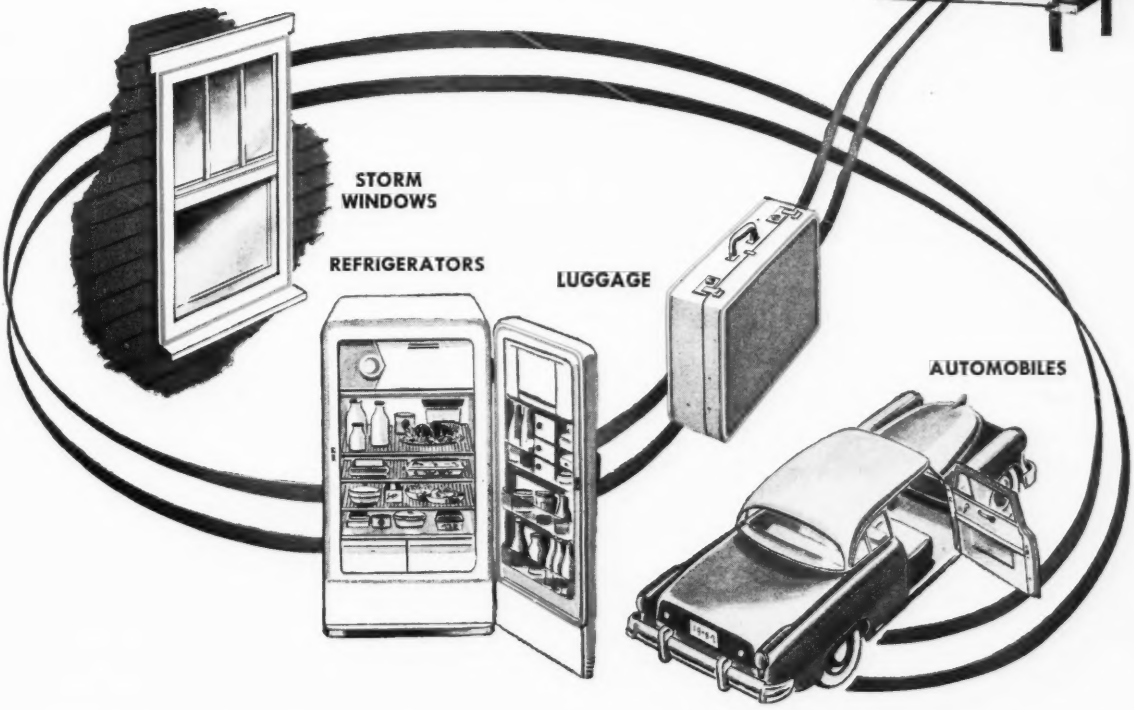

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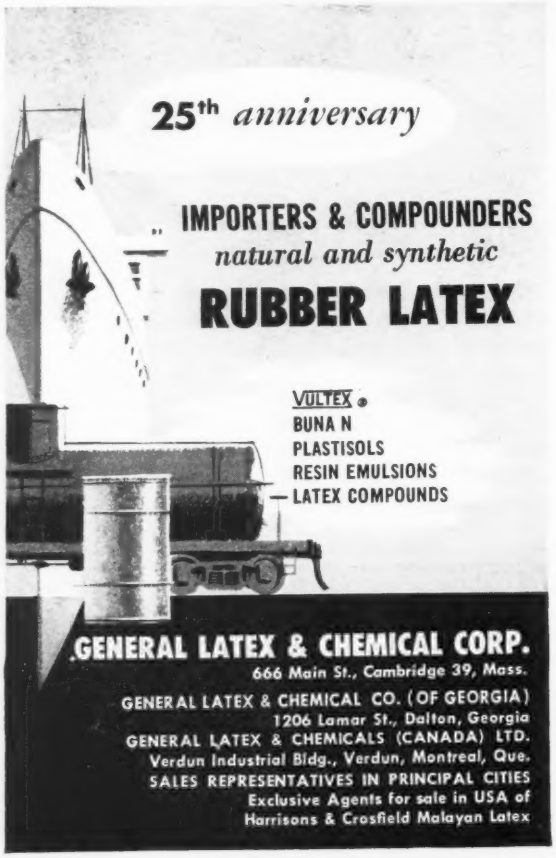

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Vigilance Still Required in Malaya

General Sir Gerald Templer recently left Malaya after completing a two-year term as High Commissioner for the Federation and has been succeeded by Sir Donald Mcgillivray. Sir Gerald's departure is generally regretted, for he came to Malaya at a critical time and thanks to his efforts Communist terrorism was considerably reduced and morale improved in all sections of the country.

The emergency, however, is by no means over. As the United Planting Association of Malaya stated in its annual report for 1953, Communist terrorism has not yet been killed here and "the times still demand vigilance, not complacency." Warnings against complacency and carelessness have also been issued by "The Planter," organ of the Incorporated Society of Planters, in recent editorials. It added that throughout the emergency the situation improved in some areas, only to deteriorate in others.

Conditions in certain parts of the State of Johore—long a sore spot—still appear intractable. In his speech at the annual general meeting of the United Sua Betong Rubber Estates, Ltd., the chairman, Sir John Hay, told of continued disturbances, with recurrent threats on property and person, in the Yong Peng area, where the company has an estate of more than 8,000 acres. Conditions there make routine operations difficult, and special undertakings, like replanting, inadvisable.

As though to justify all the warnings, there seems of late to have been a recrudescence of attacks on planters, kidnapping of workers, and destruction of trees and property in outlying sections, which may or may not have been inspired by the developments in Indo-China.

Unemployment Scheme

An unemployment scheme to provide relief work for rubber estate workers in Malaya has been drawn up by a special government-appointed committee and sent to estate owners. It is suggested that when unemployment threatens, estates, instead of letting men go, put them to work growing vegetables. The work should be supervised and organized so as to be self-supporting; these costs involved are to be borne by the estates. It seems that the government, however, will pay workers during the first four to six months, but thereafter it is expected that the sale of vegetables will yield enough to provide a wage for labor.

FRANCE

December, 1954, Chemical and Plastics Exhibition

The third Salon de La Chimie et des Matières Plastiques is to be held in Paris from December 3-12, 1954. This year the scope of the exhibition is to be considerably increased. It is to include four main sections: (1) laboratory equipment; (2) chemical engineering (general and specialized plant, including equipment for the rubber industry); (3) chemical products; and (4) plastics industry.

During the Exhibition the third Conference on Chemical Engineering and the first Corrosion Conference are to be held. The following symposia are planned: analysis and testing methods; optical instruments; plant control; plastics.

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Utastop is an acid-type anti-scorching agent, or "moderator," as the manufacturer prefers to call it, recently developed by Etablissements Uettwiller, Clamart (Seine). It is a smooth, non-adhering powder, easy to weigh and handle, having little or no odor and with excellent keeping qualities, it is claimed. Furthermore it is dustless, neither toxic nor vesicant, and disperses rapidly and easily. Utastop is used in proportions varying from 0.3 to 2%, or even 3%, depending on the compound. Excessive amounts apparently have no harmful effect on aging or other properties. In comparative tests on a good quality tire tread compound, Utastop proved equal, if not superior, to the most efficient competitive products, whether domestic or imported. Its advantage seems to be particularly marked in processing light-colored mixes since the two competitive products which in other respects are equal to Utastop have the defect of considerably darkening such mixes.

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New Steam Plasticization Method

A process for plasticizing unvulcanized rubber in live steam has been patented by E. Stalinsky[1] which obviates the need of preliminary grinding and yields a more uniformly plasticized product which can be easily stored. The rubber to be treated is cut into four-inch pieces arranged on shallow perforated vats (to permit escape of condensation water) and introduced into an autoclave directly fed with steam superheated to 155-160° C. in 20-30 minutes. In tests it was found that after treatments of one hour, two and six hours, respectively, the pieces of rubber had not changed their shape; the color was but slightly darker; there was no surface flow; and the surface was only slightly tacky. As compared with untreated samples, there was a considerable gain in time required to obtain a Williams plasticity of 4, amounting to 45% for material treated for two hours, and 63% when treated six hours. The method is claimed to have no appreciable effect on the properties of the vulcanizate made from such rubber either before or after aging.

For lack of suitable apparatus, it was not possible to exceed a temperature of 160° C., but the inventor suggests that the period of treatment could undoubtedly be considerably reduced—perhaps to 30 minutes—by using steam at 200 and 250° C.

[1] French patent No. 1,016,295.

Antioxidant Discoloration and Aging Tests

At the Institit Français du Caoutchouc several new antioxidants, alone and in combination with deactivators, were tested for their effect on the color and aging of white rubber compounds.

Experiments carried out by X. Beau[1] indicated that Ionol (2,6-ditertio-butyl-4-methyl-phenol, a Shell Française product), Santowhite Crystal (Monsanto Chemical), and 2246 (American Cyanamid) give excellent results in regard to color; in the case of 2246 aging was also good. Combined with deactivator MTBZ (mercaptobenzimidazolate of zinc, produced by S.A.M.C., St. Denis) protection against aging was in most cases improved; color was somewhat impaired, but still good. The best results were obtained with 2246, which scored perfect ratings as to resistance to discoloration and crazing, and good ratings in artificial aging tests; next best was 2246 combined with MTBZ; in this case, artificial aging improved, but, oddly enough, there was an increased tendency to craze.

[1] *Rev. gén. caoutchouc*, 30, 12, 903 (1953).

Peptized Rubber Advantages

The advantages of rubber peptized on the plantations, specifically the special rubber with 40 Mooney, now made at the Indochina Rubber Research Institute, are discussed by G. Giger.[1] This type of rubber can be processed on internal mixers as well as on two-roll mills and should be of special interest to manufacturers who do not have high-capacity equipment or any large excess production capacity, or whose product requires prolonged plasticization, it is suggested.

The higher price of this rubber, necessitated by the cost of the peptizer included and the special packing, which must be strong and airtight in view of the extreme softness of this rubber, is shown to be more than offset by the considerable savings in time and power possible by its use; there are, in addition, the added advantages of a product that is very soft and at the same time very clean.

[1] *Rev. gén. caoutchouc*, 30, 12, 903 (1953).

Pleating Sheet Rubber

A method of pleating rubber sheet has been developed by P. Walter.[1] Before it is vulcanized, the plain rubber sheet is placed between two supporting sheets of thin paper or very thin aluminum foil and passed through the usual type of pleating machine. Then the whole—pleated rubber and support—is vulcanized in a hot air stove. After curing, the rubber is separated from its supports, which in certain cases can be recovered. Every known kind of pleat can be produced, and if the rubber sheet is of good quality to start with, the pleats are permanent and disappear only when the rubber deteriorates. The method is intended for use in making decorative garments, aprons, bags, etc.

[1] *Rev. gén caoutchouc*, 31, 3, 183 (1954).

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New Rubber Use Less in 1953

French rubber manufacturers used about 10% less rubber for tires, tubes, and repair materials, and 12% more for other rubber goods, in 1953 than in 1952, recently issued statistics reveal. While total rubber consumption last year at 143,070 tons was only slightly below the 1952 figure of 145,286 tons, consumption by tire manufacturers, which had risen from 83,997 tons in 1951 to 86,572 tons in 1952, dropped sharply to 77,939 tons in 1953, the lowest in the three years. By contrast, consumption for other rubber goods has been steadily increasing from 52,214.4 tons in 1951 to 58,713.7 tons in 1952 and 65,130.6 tons in 1953. Below, some of the more important consumption figures of 1953 are compared with those of 1952 (all in metric tons):

	1953	1952
Automobile tires and tubes	66,734	74,505
Cycle tires and tubes	6,085	6,865
Elastic thread	2,781.7	2,521.9
Hose and tubing	4,185.4	3,904
Belting	2,918.1	4,204
Sponge and cellular rubber	5,093.7	3,115.5
Footwear	11,818.8	10,019.9
Heels and soles	9,294.4	8,169.4
Toys and sporting goods	1,018.5	853.7
Surgical rubber goods	1,417	1,195.8
Mechanical goods	12,538.8	11,840.7
Electric cables	4,291	4,228.3
Artificial leather	1,743.4	1,636.3

It will be noted that consumption for all the types of general goods (except for tires, tubes, and belting) were higher in 1953 than in 1952; the advance in the use of rubber for sponge and cellular products is particularly marked.

Sodium Chlorite to Oxidize Rubber in Latex

Experiments in the use of sodium chlorite ($NaClO_2$) are decribed by J. Tournier.[1] A natural rubber latex, concentrated to 60-62% by centrifugation, and obtained from Indo-China, was used, and the sodium chlorite added in small doses under both neutral (pH 7, in presence of formol) and acid (pH 3-4) conditions. Both methods yield rubber with approximately the same satisfactory plasticities, but with the first, the rubbers are dark, and with the second, white. It is suggested that small doses of sodium chlorite should be useful for production on an industrial scale of latices with adhesive properties, which would yield a plastic rubber when dried.

[1] *Rev. gén. caoutchouc*, 31, 1, 46 (1954).

GREAT BRITAIN

Footwear Imports Up; Rubber Resin Products Shown at Industries Fair

Imports of rubber and rubber-soled canvas shoes into England from Hong Kong have increased considerably in the last three years, according to figures supplied by the President of the Board of Trade in response to a recent request for information made in the House of Commons.

In the first four months of 1954, Hong Kong supplied 269,737 dozen pairs of rubber-soled canvas shoes and 52,386 dozen pairs of other rubber footwear, as compared with 128,331 and 18,764 dozen pairs in the same period of 1953, and 97,389 and 9,365 dozen pairs, respectively, in the 1952 period.

Rubber-phenolic resin compounds were used for a variety of products shown for the first time at this year's British Industries Fair, at Birmingham. Containers and pails, of various shapes and sizes, chiefly for factory use, and also wheelbarrows, are made from the material, marketed under the name Fortiflex, which is a new development of Dunlop Rubber Co., Ltd.

The rubber-phenolic resin compounds are said to combine flexibility and resilience with strength and good form-retaining properties; they have high resistance to corrosion, also to tearing and surface cracking; they are lighter than metal, and are also claimed to compare favorably with polyethylene, being cheaper and more flexible. Initial cost of Fortiflex products is higher than for metal equivalents, but this increase is offset by the many advantages their use offers.

Some of the articles displayed at the Fair are now in limited production; others are still in the development stage.

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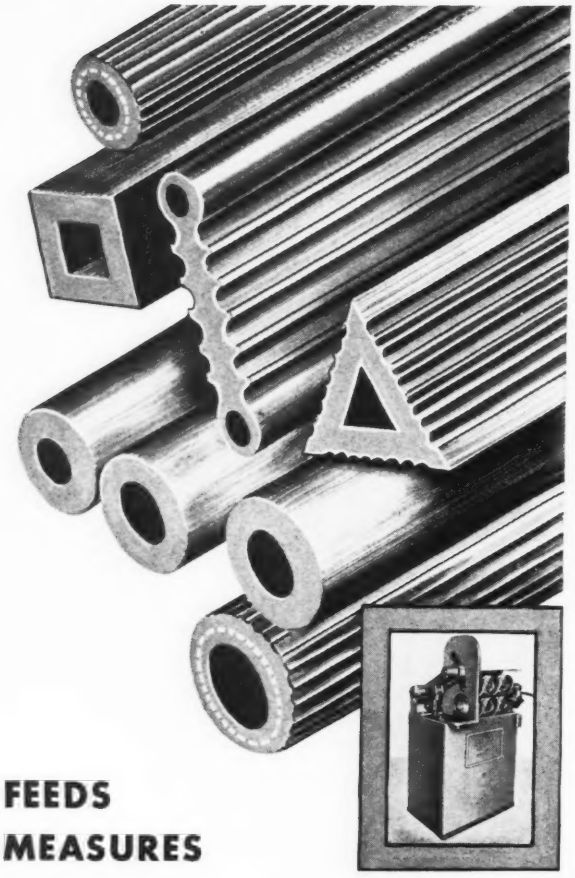

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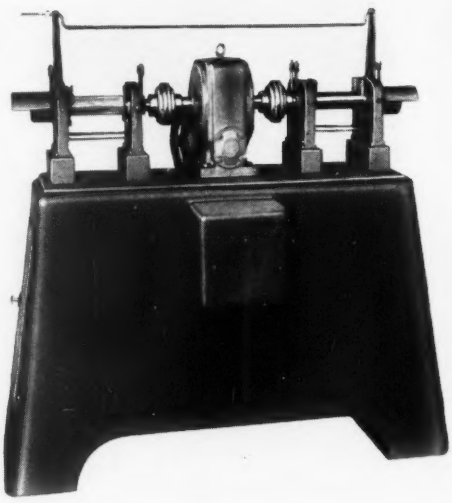
W. J. Westaway Co., Ltd., Hamilton, Ontario, Canada *Export Dept.*, 25 Beaver Street, New York 4, N. Y.

New Machinery



Stewart Bolling Mill-Cracker

Mill-Cracker for Laboratory Use

A LABORATORY-SIZE dual cracker and mill has been made available to industry by Stewart Bolling & Co., 3192 E. 65th St., Cleveland 27, O., following its introduction at the 1954 National Plastics Exposition. The cracker, located on one side of a gear reducer, consists of one smooth and one corrugated roll for quick reduction of lump stocks.

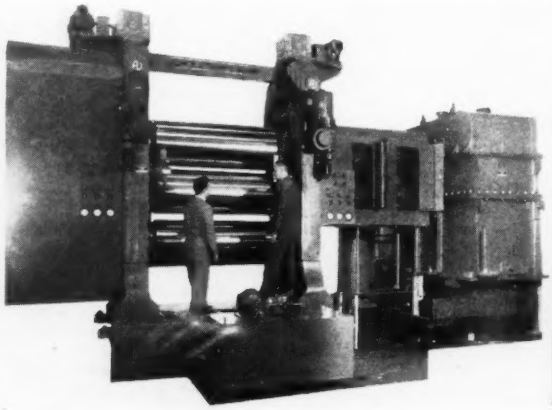
On the other side of the reducer is a two-roll midget mill for compounding plastic or rubber stocks. The rolls are 2½ inches in diameter, with a seven-inch face, and are equipped with ball-bearing rotary pressure joints having flexible bronze connections.

Both units are driven by a single two-hp. motor, and mounting of the device is on a code height cabinet-type base. Knee switches operate a safety brake. Dimensions of the overall machine are five feet wide by four feet high by 2½ feet deep.

Three-Roll Calender with Crossed-Axis Device

THE availability of a three-roll sheeting and coating calender for rubber has been announced by Adamson United Co., 730 Carroll St., Akron 4, O. Feature of the 24- by 68-inch vertical machine is a crossed-axis device for compensating crown during operation.

The calender is driven by a separate pinion stand and uni-



24- by 68-Inch Three-Roll Calender

Bloom PROBLEMS?

Stauffer CHEMICALS SINCE 1885

CRYSTEX 85% Insoluble Sulphur

CAN SOLVE THEM AND:

1. improve product quality and appearance

Crystex, because of its high insolubility in rubber, cannot migrate and "bloom" like ordinary sulphur in your rubber compounds. This assures better surface appearance, particularly important in white side-walls and other light colored consumer goods in which "yellow spots" would be objectionable.

By preventing bloom, Crystex improves the tack of built-up stocks such as tire carcasses, belting, and valve patch frictions, thereby guaranteeing good adhesion after vulcanization.

2. save on plant operation costs

A stock blended with Crystex can be kept for long periods before vulcanization without the danger of blooming. Mixing and vulcanization schedules can be made more flexible to permit maximum utilization of machinery and labor without the worry of a "time element" imposed by the danger of bloom.

3. increase compounding flexibility

Formulating with Crystex will allow variations to be made in factory recipes that tend to be "scorchy"; its use will control the degree of tackiness of factory stocks. The unusual characteristic of being insoluble in "anything and everything" except more sulphur may suggest additional uses in your formulations.

Enthusiastic acceptance of Stauffer CRYSTEX by the rubber industry has necessitated the construction of a new plant, and CRYSTEX is now produced at both Chauncey, N.Y., and Monongahela, Pa. Packed in 50-pound multiwall paper bags, Stauffer CRYSTEX is available in all quantities up to car-load.

Write for experimental samples or further information on the properties and uses of CRYSTEX.

STAUFFER CHEMICAL COMPANY

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221 N. LaSalle St., Chicago 1, Ill. • 636 California St., San Francisco 8, California
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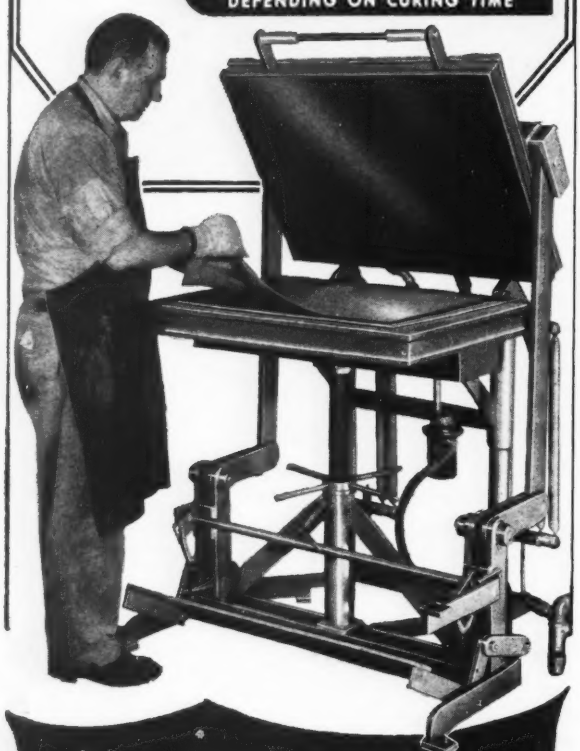
ONE MAN CAN OPERATE
FROM 1 TO 17 . . .

SPONGE RUBBER
VULCANIZING PRESSES
. . . Simultaneously
DEPENDING ON CURING TIME



Original Cost . . . 80% Less

ith The HOLMES SPONGE RUBBER VULCANIZING PRESS--there's no effort, no exertion, no operator fatigue. Mold remains set --no need to separately lift it each time. Locking and release is accomplished by simple foot action. Thus one man can operate from 1 to 17 at a time. Costs 1/5 of any other press that will do the same work.

WRITE OR WIRE FOR SPECIFIC DETAILS--regardless of your particular requirements. With 52 years know-how specializing in machinery and molds for the rubber industry--Holmes can help you solve your problems, too, just as they have for so many others. No obligation, of course.

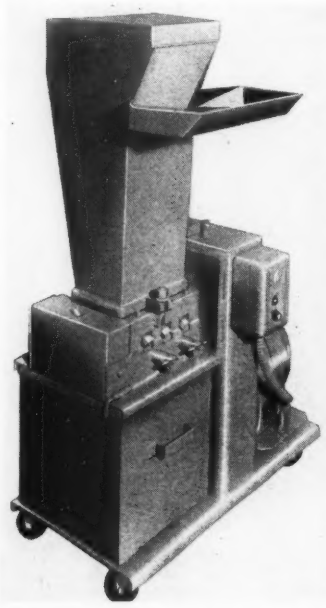
SEND FOR ILLUSTRATED FOLDER...TODAY

HOLMES

Successor to Holmes Brothers, Inc.

versal coupling, allowing top roll to be crossed by means of a motorized device, to compensate for variable deflection. This allows the operator to change the crown at will, in effect, to compensate for changes in speed, temperature, gage, compounding, etc. Equipped with chilled-iron rolls of the peripherally-drilled type, the calender employs a circulating water system to achieve temperature control.

Space required for the new unit is claimed to be little more than for a conventional calender, since the main drive motor can be mounted between the calender and the pinion stand.



Injection Molders' New Plastic Grinder

Elastomeric Grinder

FOR clean cutting of soft plastic materials such as vinyl and polyethylene which cannot be successfully handled in conventional grinders without fluffing, Injection Molders Supply Co., 3514 Lee Rd., Cleveland 20, O., has introduced a new Elastomeric Grinder. The unit is constructed with an unrestricted throat measuring 5⅜ by 8½ inches, through which the plastic drops into a special cutting chamber equipped with two rotating and two stationary knives. These high-angle knives are designed to cut without tearing, the company reports.

The screen, available in ¼ or 5/16-inch sizes (and others), can be removed easily by pulling out two spring-loaded plugs. Two-hp. motors are supplied with the units, and three-hp. motors are available. A material catch pan and a set of casters for the entire unit are also provided. Other specifications include: overall height, 54 inches; required floor space, 30 by 18 inches; rotor speed, 500 rpm. (with two-hp. motor); power source, 220/440 volt, 60-cycle, three-phase current; and capacity per hour for styrene, 150 pounds.

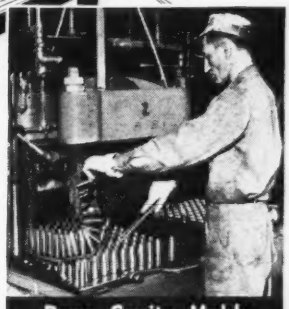
50-Ton Compression and Transfer Presses

A 50-TON model of both the Model *726* compression molding press and the Model *727* transfer molding press have been added to the line of semi-automatic molding presses manufactured by F. J. Stokes Machine Co., Philadelphia, Pa. Both units are suitable for use either by themselves or as additions to existing equipment; both are high-speed, self-contained, fully hydraulic presses; both have a ram speed reported to be highest among standard molding presses; and both feature the company's patented bar-type controller. This controller provides automatic control over every phase of the molding cycle by means of buttons on graduated bars. Settings of the controller, rapidly adjustable, can be recorded to permit repetition of the cycle at will.

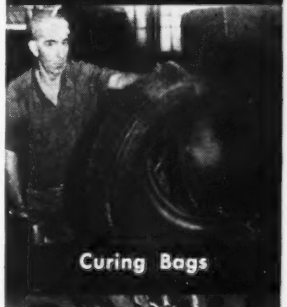
The new Model *726* is a straight ram press especially designed to do deep-draw work at high speeds. It has a three-speed closing action, consisting of a high-speed initial ram approach, a slower intermediate approach, and a final closing speed which is only as fast as the material plasticizes; the result is a product of high density and uniformity, the company states. The press is also equipped with a double-acting ram which eliminates the need of external pull-back cylinders and their accessories.

The new Model *727*, available with either a top or bottom plunger, is constructed with two hydraulic systems to permit separate adjustment of the pressure and speed of each cylinder. Model *727* has an extra-long transfer stroke which permits complete withdrawal of the plunger from the loading area, and is designed to accommodate both top and bottom ejection molds. Model *727* also incorporates the three-speed closing and the double-acting ram features of *726*.

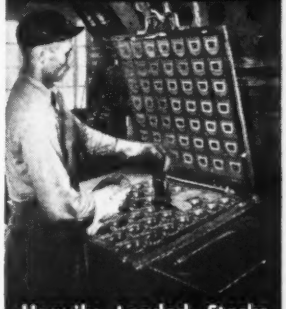
Dow Corning Release Agents keep molds cleaner, longer!



Deep Cavity Molds



Curing Bags



Heavily Loaded Stocks

It takes a "snooper" glass to find dirt on a mold that stays clean enough to serve as a mirror. And that's what you get when you use Dow Corning mold release agents. Molds stay clean 5 to 10 times longer than they do with ordinary lubricants because Dow Corning silicones don't break down to form carbonaceous deposits on mold surfaces. And, clean molds also mean clean release of tires and mechanical rubber parts with sharper detail, closer tolerances and a high finish that adds sales appeal. You also benefit from longer productive runs, less scrap and lower operating costs.

New price reductions of up to 8% make Dow Corning Silicone release agents more economical than ever. So for easier release, lower costs, improved quality and better appearance—specify Dow Corning Mold Release agents; Fluid for green carcasses, beads and parting lines; Emulsions for molds, mandrels and curing bags.

For more information call our nearest branch office or write direct for Data Sheet M-20.

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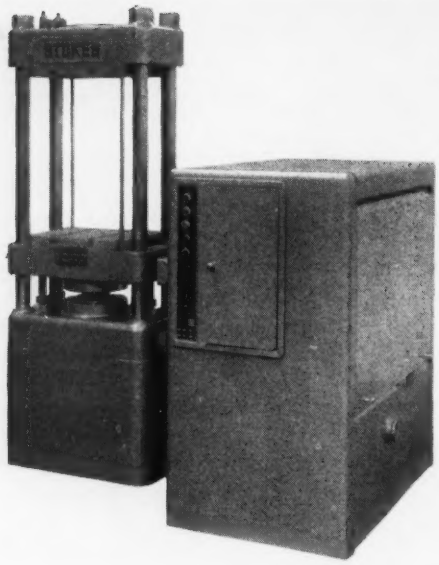

Model 726 Compression Molding Press

Optional equipment with both presses include hot plates for either steam or electric heating, water cooling of molds, and adjustable head with or without longer tie-rods.

Temperature Test Chamber

AN INDUSTRIAL test chamber in which it is reportedly possible to change from 600° F. to —100° F. within two hours is now being produced by Conrad Inc., Holland, Mich. In addition to this quick-change feature, the new chamber can control its temperature within two degrees of the set point, can increase or decrease its temperature within any range and at any rate, and can be provided with controls to permit recurrent cycle operation, according to the company.

Major advantage of the device is that it takes the place of two units, for heating and cooling, respectively. This reduces the amount of equipment necessary to conduct such tests and eliminates movement of the test specimens.

The fast drawdown of the temperature is produced by forced venting of the heated air, and at 200° F. by the use of a double-cascade cooling unit. It is also claimed that cooling from ambient temperatures to —100° F. can be accomplished in one hour, and that the device is completely safe since Freon 13 and Freon 22 are employed in the system.

Conrad Heat-Freeze Test Chamber

For highest quality

HAF-SAF BLACKS

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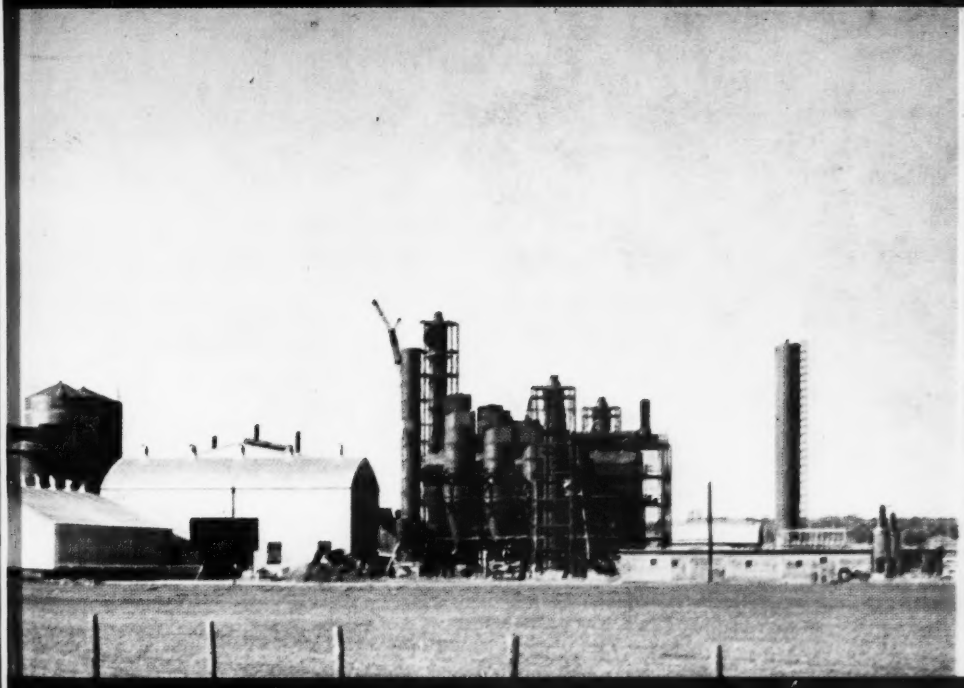

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Continex HAF—Oil Type, High Abrasion
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New Materials

Dry Stearate Spray Bomb

DRY powder zinc stearate for use as a mold release agent is now available in aerosol bombs from Injection Molders Supply Co., 3514 Lee Rd., Cleveland 20, O. The company believes that the new product will replace makeshift applicators which waste powder and cause abrasive wear on machine tie bars and moving mold parts when the excess powder settles.

Another mold release in bomb form, this one a Silicone spray, is also produced by the firm.

Gilsonite Extender—Millex

MILLEX, a selected Gilsonite specially compounded to render it readily miscible with rubber and rubber-like materials, is available from Cary Chemicals, Inc., successor to Burgess Chemical Co., 64 Hamilton St., Paterson 1, N. J. The product can be used in GR-S, natural, or reclaimed rubber to improve processing and fatten stocks without undue softening, according to the manufacturer. Its use in vinyl resins that are to be molded into semi-rigid, dark products is also possible.

Dark brown in color, Millex is a friable solid with relatively low hiding power. Its physical properties include: specific gravity, 1.04; melting point, 250° F. (approximately); and odor, slightly asphaltic.

PerchloroMethyl Mercaptan—PMM

COMMERCIAL quantities of PMM, perchloromethyl mercaptan, for use as a reactive intermediate in the manufacture of rubber additives, are now available from Stauffer Chemical Co., 380 Madison Ave., New York 17, N. Y. The primary chemical activity of PMM centers about the reactive sulphur-linked chlorine atom, permitting reactions with amides, imides, olefins, thiols, xanthates, sodium alkoxides, and all amines.

Typical reactions and properties of this chemical, as contained in the company's technical bulletin No. 531, are as follows: appearance, pale yellow oil; boiling point, 149° C.; density, 1.700 grams per milliliter at 20° C.; surface tension, 35.02 dynes per centimeter; and solubility, soluble in organic solvents.

Nitrile Latex—Nitrex 2614

A NITRILE-TYPE synthetic latex, reported capable of being vulcanized at low temperatures with zinc oxide and without the addtion of sulfur or accelerators, has been developed by Naugatuck Chemical division of United States Rubber Co., Naugatuck, Conn. Designated Nitrex 2614, the new material was developed by the company to give good adhesion to cellulose.

Besides the outstanding vulcanization property, which requires only the addition of zinc oxide paste to the latex in order to be effected, Naugatuck also claims that cured films of this material exhibit considerable resistance to oil and solvents, good adhesion to many surfaces, and excellent resilience. The latex is also capable of being extended with fillers, blended with other latices, and thickened with conventional agents.

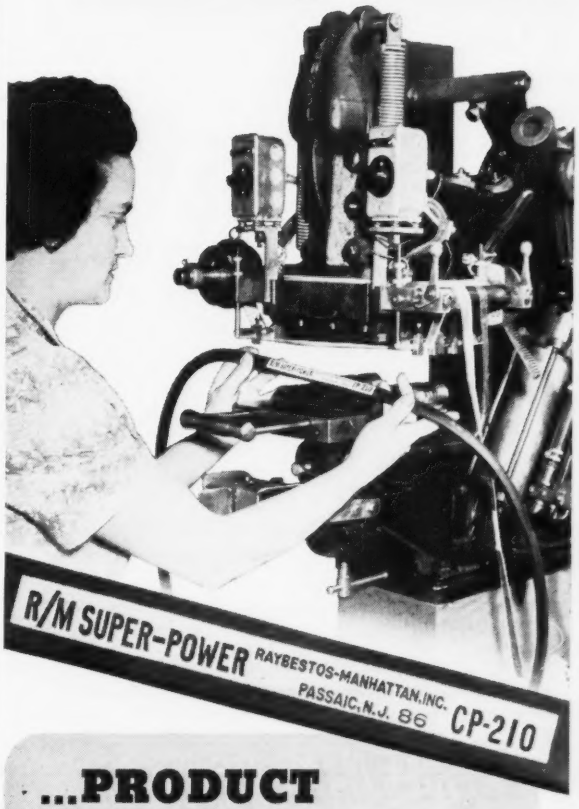
General properties of Nitrex 2614 are represented as follows: total solids, 38-40%; weight, 8.3 pounds a gallon; pH value, 7-9; viscosity, low; antioxidant, non-staining; film odor, none.

Basic Silicone Rubber Polymer Gum

DOW CORNING 400 GUM, one of the basic silicone rubber polymers of Dow Corning Corp., Midland, Mich., has been made available to industry by the company. Clear, uniform, and non-toxic, this material can be compounded with a wide range of fillers and vulcanizing agents to produce silicone rubbers suitable for a variety of applications.

The new material is described in a recently published brochure, "Compounding Silicone Rubber with Dow Corning Gum," along with information on recommended fillers, vulcanizing agents, low compression set additives, and other general compounding data, with graphs, tables, and text. This gum is

NEW Method for Marking Rubber



...PRODUCT IDENTIFICATION by SWIFT Colors

Raybestos-Manhattan have selected Swift colors to mark their line of V-belts. The use of Swift colors assures them of a top-notch trade-mark throughout the long life of the belt and is a good reminder when it's time to re-order.

If you are looking for an easy method of trade-marking your rubber product with bright, long lasting colors, Swift may have the answer. Send us a sample to mark. We think you will be pleasantly surprised.

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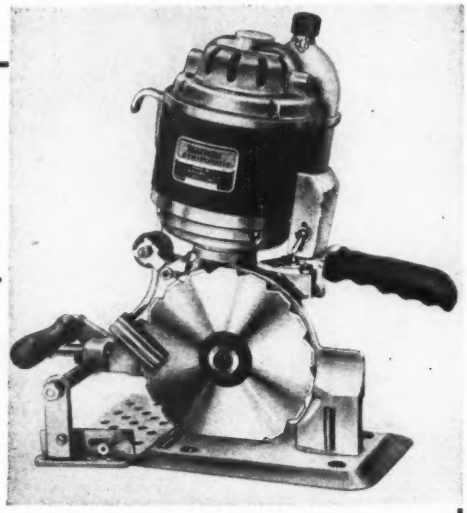
STRIPOMATIK
by MAIMIN



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represented as a dimethyl silicone gum of high molecular weight and extremely high viscosity. Convenient and easy to handle with conventional compounding equipment, it is stable in storage and requires no preliminary breakdown. Specifications include: Williams plasticity, 45 mils; specific gravity (at 25° C.), 0.98; and brittle point (when compounded), —80° F.

Heating a blend of Dow Corning 400 Gum and certain peroxide vulcanizing agents converts the mixture to a cross-linked, resilient mass. The selection of inorganic fillers and additives, however, determines to a large extent the physical properties of the finished elastomer, according to the company.

Ohio-Apex Primary Vinyl Plasticizers

FOUR new primary vinyl plasticizers, Dinopol IDO, Adipol 810, Kronitex K-3, and Kronitex MX, were recently announced as available from Ohio-Apex Division, Food Machinery & Chemical Corp., Nitro, W. Va.

Dinopol IDO (iso-decyl octyl phthalate), comparable in price and in most properties to DOP (dioctyl phthalate), produces plastics wth much lower air loss than does DOP, according to the manufacturer. Adipol 810 (iso-decyl octyl adipate), comparable in low-temperature flexibility properties and in price to the octyl adipates, results in products with much lower volatility than are obtained with those materials. Both Kronitex K-3 and MX are tricresyl phosphates with properties comparable to that chemical family; they have the advantages of lower specific gravity and lower volatility, and of lower viscosity and better low-temperature flexibility, respectively, over other such phosphates, the company states.

All plasticizers are soluble in most organic liquids but insoluble in water, and all have slight odors. Ohio-Apex gives the following tentative specifications and properties for the materials:

	Dinopol IDO	Adipol 810	Kronitex K-3	Kronitex MX
Specific gravity, 20°/20° C.	0.975±0.005	0.924±0.005	1.143±0.005	1.195±0.010
Moisture content, %, max.	0.1	0.1	0.1	0.1
Acidity, %, max., as acetic acid	0.01	0.03	0.01	0.01
Freezing point, °C. (stiff gel)	−55	−38	−21	−30 to −35
Boiling range, °C., at 4 mm. Hg	234–253	215–240	250–266	235–255
Flash point, °C.	216	204	263	238
Surface tension, dynes per cm., at 20° C.	30.4	29.7	37	42
Viscosity, cps., at 20° C.	90±5	20	220–300	60–70

Lignin-GR-S Masterbatch — Indulin-70-GR-S

A DRY masterbatch, described as a coprecipitated, very intimate admixture of 70 pounds of lignin and 100 pounds of GR-S latex, is commercially available in tonnage quantities from West Virginia Pulp & Paper Co., Charleston, S. C. Known as Indulin-70-GR-S (Indulin is the company's trade name for lignin), the material is formed by adding lignin as an alkaline solution to the GR-S 1500 latex and then coagulating with an acid in the usual manner.

This coprecipitation produces a product similar to the black masterbatches available from government-owned GR-S plants. Study of this type of lignin-GR-S masterbatch[1] indicates superior strength properties in some cases.

In processing Indulin-70-GR-S, the high volume of loading (54 volumes per 100 volumes of rubber) necessitates care to prevent overloading the machinery. The initial stock is stiff, and the power requirement is high. A recommended procedure is to operate the Banbury without any pressure on the ram until after the stock has been broken down. Some processing aids are more effective than others, and coal tar plasticizers are generally recommended, with stearic acid as the lubricant.

The new material can be compounded without the addition of any other pigments or rubber, using only curing chemicals. Or it can be loaded with a high percentage of pigments. Both these conditions are described in Technical Bulletin No. 113A of the company, and some of the resulting properties (at room temperature) are given as follows:

	Indulin-70-GR-S	
	Without Pigments	With Total Pigment Volume Loading of 78.4
Tensile strength, psi	3400	2450
300% modulus, psi	1300	2200
Elongation, %	650	380
Hardness, Shore A	94	93
Abrasion loss (NBS), cc/100 cycles	0.31	0.77

[1] "Effect of Coprecipitation Conditions on Filtration and Properties of Lignin Reinforced GR-S." J. J. Keilen, W. K. Dougherty, W. R. Cook, India RUBBER WORLD, May, 1951, p. 178.

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New Goods

Cut-a-Way Section of New Conveyor Belt Containing Wire Barriers

Conveyor Belts with Wire Ribbons

RIBBONS of high-tensile steel wire, inserted at intervals up to three feet, feature a new type of rubber conveyor belt developed by The B. F. Goodrich Co., Akron, O. The wires act as barriers to prevent accidental rips from running the entire length of the belt.

Positioned beneath the first fabric or cord ply and placed across the width of the belt, the wire ribbons are used in combination with the company's transcord breaker or longitudinal nylon cord breaker. This type of construction, presently available in a variety of belts, including all types of hot material units, is said by the manufacturer to increase the belt life up to 50%.

General-Purpose Hose

THE development of a hose intended for general industrial use has been announced by Republic Rubber Division, Lee Rubber & Tire Corp., Youngstown, O. Known as Conductall, the product is represented as a multi-purpose unit capable of conducting air, oxygen, acetylene, water, oil, grease, gasoline, and dilute chemical and acid solutions. It is not recommended for handling lacquer, lacquer solvents, or steam.

Air-operated tools for welding and cutting, service station application, etc., are suggested uses for Conductall which is available in sizes from 3/16-1½ inches.

In construction, the tube and the cover of the product are made of an oil-resisting Reprene compound, and the carcass is reinforced with braided rayon cords for strength and long life. Feature of the hose is the lead press-cured black cover, which is molded smooth for easy handling.

Silastic Coating for Glass Cloth

AN IMPROVED silicone rubber coating for glass cloth or synthetic fabrics has been developed by Dow Corning Corp., Midland, Mich. Retaining the name and basic properties of Silastic 132, the compound it replaces, the new material features greatly increased crease resistance and excellent retention of dielectric strength, according to the company.

Available in the form of 100% solids or as a 35% dispersion in xylene, the new material is claimed to be less sensitive to processing temperatures than comparable silicone rubbers. When coated to a thickness of 10 mils on ECC 116 heat-cleaned glass cloth, this new coating is said to impart the following tensile strength, in pounds per inch, to the fabric:

	Uncreased	After Four Creases
Lengthwise	140	140
Crosswise	135	130
Lengthwise, after 96 hours at 200° C.	145	95

Dow also reports that similarly coated samples exhibit a dielectric strength of 1,100 volts per mil both "as received" and after 21 days at 250° C.

Hi-Miler Truck Tires

TWO new tires have been added to the Hi-Miler line of Goodyear Tire & Rubber Co., Akron, O. Both feature increased body strength as a result of the use of rayon tire cord which has been pre-stretched in the company's triple-tempering operations.

The Traction Hi-Miler, available also with all-nylon cord, provides greater traction and longer tread life (by 47%), in addition to the greater heat and bruise resistance from the stretched cord, than was obtained with previous models. Goodyear also claims that the five zigzag ribs and deep stop-notches contained in the tread give at least 24% more skid resistance than competitive units.

Goodyear Traction Hi-Miler Truck Tire

The Hi-Miler Rib truck tire is also described as having an improved tread and an increased traction tread design. Intended as a replacement for the company's Marathon tire, the popularly priced Rib model is expected to exhibit increased recapping possibilities.

Both Hi-Miler tires are available in all popular truck tire sizes.

High-Capacity Truck Tire

NXP Super Nylon, a new type of high-capacity nylon truck tire that will reportedly permit a reduction in the weight and the size of tire, tube, and wheel assembly, while providing an increased carrying capacity, is another recent addition to the truck tire line of Goodyear. The new product has been tested by a truck operator on the West Coast, the company states, and has been shown to be superior to many other types, including those which have a wire cord construction.

Designed to fit the specific requirements of operators seeking to boost the cubic-foot capacity of their trailers while remaining within the present overall dimensional limits, the unit is distinguished in appearance from conventional-type tires by a new size marking.

Frank Leahy Football Shoes

Canvas Topped Football Shoes

FOOTBALL shoes with canvas tops and rubber cleats are being made by United States Rubber Co., Rockefeller Center, New York 20, N. Y., for use by amateur as well as professional players. Called the Frank Leahy football shoes, the Pro-Keds were successfully tested at Notre Dame University while Mr. Leahy was head coach there, according to the company.

Light in weight, comfortable, and completely washable, the shoes are designed with cleats permanently molded in the midsole, a hard toe for kicking, and a fully cushioned insole. Mr. Leahy reports that the footwear performs equally well on hard or muddy turf and is less damaging to the feet of players.

The new shoes are manufactured in black in sizes 5-13.

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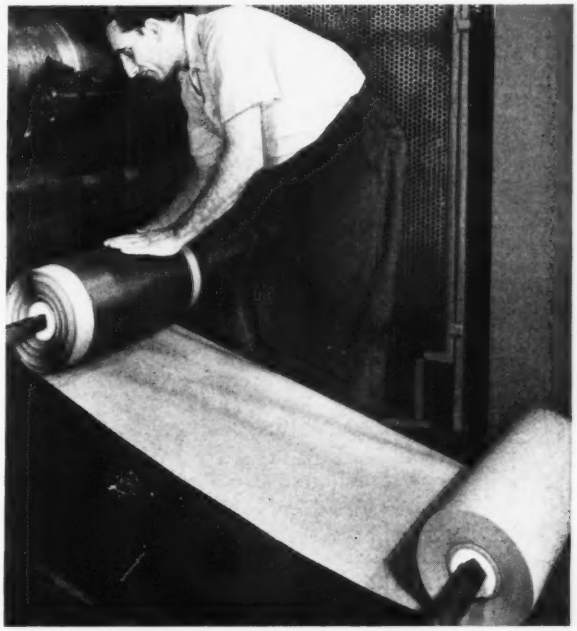
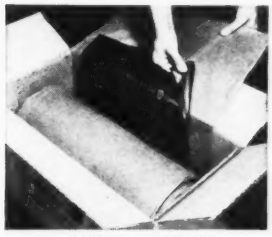


The new releasing types of Patapar Vegetable Parchment offer definite advantages over other materials as a protective packing or wrapper for tacky substances. Their dense, fibre-free surfaces release easily from a wide variety of uncured, natural or synthetic rubbers. They are effectively used as separator sheets for uncured rubber, rubber tape, and as backing for pressure sensitive surfaces.



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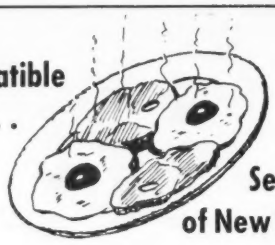

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Editor's Book Table

BOOK REVIEWS

"Induction and Dielectric Heating." J. Wesley Cable. Reinhold Publishing Corp., 330 W. 42nd St., New York 36, N. Y. Cloth, 6 by 9 inches, 583 pages. Price, $12.50.

This book presents a wealth of practical information on methods of applying high-frequency heating in industry. The text is divided into two sections: the first, comprising 11 chapters, covers induction heating; and the second section, consisting of 13 chapters, is devoted to dielectric heating. Each section begins with a discussion of the theory involved; the energy sources and their principles of operation; and the design of coils and electrodes. Subsequent chapters describe applications in different fields, including the rubber and plastics industries. Chapters are also devoted to the mechanization of the heating equipment to adapt it to production lines. A discussion of radio interference by high-frequency heating equipment is given in an appendix, and a subject index concludes the book.

"Modern Chemical Processes, Volume III." By the Editors of *Industrial and Engineering Chemistry*. Reinhold Publishing Corp., 330 W. 42nd St., New York 18, N. Y. Cloth, 8 by 11⅛ inches, 281 pages. Price, $5.

This third volume of the series includes 23 factual and authoritative articles on recently developed chemical processes now in full-scale operation. Prepared by the editors of *I & EC* in conjunction with the technical staffs of cooperating organizations, the articles were originally published in that magazine. Each process is described with respect to commercial and technical background; plant installation; process and plant operation; process economics; plant personnel; and future prospects of the process.

The current volume contains articles on certified food colors; ammonia at 1,000 atmospheres; an American Fischer-Tropsch plant; oil black; oil gas manufacture; chemicals from milk; formaldehyde from methanol; hydroquinone; lactic acid from corn sugar; animal glue; cellophane; carboxymethylcellulose; acetophenone; diatomaceous earth; ammonia nitrate; dextran; chemicals from oranges; chlorine and caustic in Italy; nitric acid in Great Britain; flushed color production of peacock blue; mercury cell chlorine and caustic; catalytic asphalt; and Wulff Process acetylene.

"Technical Writing." Gordon H. Mills and John A. Walter. Rinehart & Co., Inc., 232 Madison Ave., New York 16, N. Y. Cloth, 6 by 9 inches, 475 pages. Price, $4.50.

This book is a commendable attempt at a logical bridge between the professional writings of scientists and engineers and the contents of a course for students of technical writing. The text is divided into six sections; the first section, on preliminary problems, deals with introductory material, basic principles of good technical writing, style, and outlines and abstracts. Special techniques of technical writing are covered in the second section, and the use of transitions, introductions, and conclusions are described in the third section. Types of reports, including oral reports, business letters, and writing for professional journals, are discussed in the next section. Report layout is covered in the fifth section, and a section on library research reports concludes the text. Many examples of actual reports are used to clarify the subject matter, and appendices include a bibliography, further examples of published reports, a list of approved abbreviations of technical terms, and a subject index.

NEW PUBLICATIONS

"Rubatex Newsletter." No. 1, June 15, 1954. Rubatex Products Inc., New York, N. Y. 3 pages. This issue is the first of a series of Newsletters which will be sent to Rubatex licensees to acquaint them with the research and development work being carried on by the company at its Melrose, Mass., laboratory, and other information on the firm's products. This issue covers the important steps in closed-cell rubber manufacture, and is signed by R. J. Noble, vice president, research and development.

"Foxboro Needle Type Control Valves." Bulletin 5C-13. The Foxboro Co., Foxboro, Mass. 8 pages. Design details, operating characteristics, and related information are given for the company's line of needle valves suitable for precise control of low rates of flow.

"Morpholine (Including Data on 'Morlex' Corrosion Inhibitor A)." Carbide & Carbon Chemicals Co., 30 E. 42nd St., New York 17, N. Y. 8 pages. This technical bulletin (F-8488) presents information on properties, specifications, shipping data, safe handling practices, and suggested applications of this amine. Morpholine is a reactive material with many important commercial applications, including use for making rubber accelerators.

"Multiply Profits." Monsanto Chemical Co., Springfield, Mass. Profit possibilities in products molded from granulated wood are outlined in this illustrated pamphlet.

"Dodecenyl-Succinic Anhydride." Technical Bulletin I-8. National Aniline Division, Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y. 6 pages. This attractive folder, of interest to producers of natural and synthetic rubbers, plastics, and paints, among others, gives the properties of this anhydride and suggests uses for it. Two graphs are included: one shows the infrared absorption spectogram of the material; while the other indicates the effect of temperature on the viscosity of dodecenyl-succinic anhydride.

"The Nitroparaffins." Technical Data Sheet No. 23. Commercial Solvents Corp., New York, N. Y. 8 pages. This publication describes the physical properties, specifications, chemical reactions, and uses of nitromethane, nitroethane, 1-nitropropane, and 2-nitropropane.

"Engineering Services." Foster D. Snell, Inc., 29 W. 15th St., New York 11, N. Y. 12 pages. This illustrated booklet describes the services available from the engineering division of the company.

"Hycar Technical News Letter." Vol. 3, No. 6, June 1954. B. F. Goodrich Chemical Co., Rose Bldg., Cleveland 15, O. 4 pages. This issue, devoted to footwear, deals specifically with non-skid Hycar work-shoe soles; Good-rite 50 as a reinforcing agent for shoe soles; and toplifts. Detailed formulations for these various products complete this Newsletter.

"Hycar Latex Newsletter." Issue No. 7, June, 1954. 4 pages. This issue contains formulations and data relative to the use of Hycar latices in the upholstery field.

Publications of Dow Corning Corp., Midland, Mich., for inclusion in the "Silastic Notebook":

"Silastic Facts." 9-338. 2 pages. Silastic 7-181 low compression-set stock is discussed, with physical properties and recommended applications, in this catalog insert.

"Silastic Notebook Contents." 7-1-54. 3 pages. This listing gives a suggested order in which past and future publications on Silastic should be arranged for quick reference.

"Silastic Notes." Preliminary Data 9-211. 2 pages. Room temperature vulcanizing (RTV) Silastic stock is described herein with mixing, working time, and curing data, and with properties and applications of the material.

Publications of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.:

"Butyl Accelerator 21." W. G. Ogden. Report No. 54-2. 12 pages. The physical properties obtainable by using this accelerator, a combination of Thiuram M and MBT, in various recipes are presented in this report.

"'Hypalon' for Tank Linings for Corrosive Chemicals." BL-258. 6 pages. The compounding, processing, and fabrication procedures recommended for making and installing tank-lining sheet stock of Hypalon are given here.

"Tepidone for Low Cost Curing of Latex Compositions." BL-259. 6 pages. The use of Tepidone, an active latex accelerator of 47% sodium dibutyl dithiocarbamate in water, in rubber, in GR-S, and in neoprene is considered in this publication, with the recipes and physical properties of the resulting stock given.

"The Use of Neoprene Type WRT in Neoprene Jacketed Flexible Cords." BL-260. 3 pages. Data presented demonstrate that this type of general-purpose neoprene has the greatest resistance to crystallization, a property which suggests its use in flexible cords.

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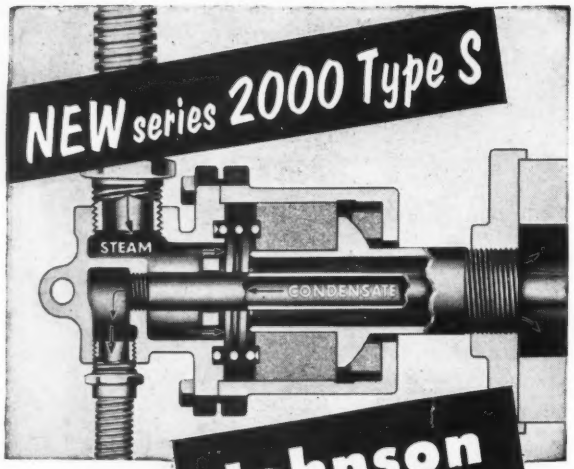

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"Zeolex 23, Compounding Study and Physical Data." J. M. Huber Corp., 100 Park Ave., New York 17, N. Y. 20 pages. Detailed formulations and test data compare Zeolex 23 with calcium silicate in GR-S, natural rubber, natural-GR-S blends, oil-extended GR-S, neoprene, Butyl, nitrile rubber, and Hypalon.

"Use of Glycol in Nitriles." Columbia-Southern Chemical Corp., Pittsburgh 22, Pa. 4 pages. This publication, intended for insertion in the company's "Pigment Binder" as a replacement for pages within "Silene Bulletin No. 2," gives additional technical information on the subject by presenting the physical properties obtainable with certain recipes.

"Retailers' Plastics Manual." The Society of the Plastics Industry, Inc., 67 W. 44th St., New York 36, N. Y., and The Manufacturing Chemists Association, Inc., 1625 Eye St., N.W., Washington 6, D. C. 44 pages. This joint contribution of these two associations offers basic facts on 12 major plastics aimed at helping the consumer to buy better and the dealer to sell more plastic products. Salient points are aimed at the following: For what products is each plastic suited? What is special about each plastic? How do you care for each plastic? Plastics particularly dealt with are: acetate, acrylic, butyrate, casein, cast phenolic, cellulosics, ethyl cellulose, melamine, nitrate, nylon, phenolic, polyesters, polyethylene, polystyrene, reinforced polyester, Saran, urea, and vinyl. A glossary of terms and a list of trade names add to the value of this nicely illustrated manual.

"Vulcan 3, Vulcan 6, and Vulcan 9 in Cold GR-S." Technical Service Laboratory Bulletin No. GD-9. T. D. Bolt. Cabot Research Laboratories, Cambridge, Mass. 2 pages. Cold GR-S tread stock was loaded with 35, 40, 45, and 50 parts per hundred of these carbon blacks in an attempt to determine the optimum loading. The data collected by laboratory testing of the resulting stocks are presented in this bulletin.

"Geon Technical Newsletter." July, 1954. B. F. Goodrich Chemical Co., Rose Bldg., Cleveland 15, O. 4 pages. Two articles, "Formulated Geon 103-EP Rigid Compounds," covering an investigation of stabilizers and fillers for this stock, and "Effect of Plasticizers on the Flammability of Vinyl Film," are contained in this publication.

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GR-S Developments

(*continued from page 654*)

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[12]Abstract.

VULCANIZED VEGETABLE OILS

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•

Types, grades and blends for every purpose, wherever Vulcanized Vegetable Oils can be used in production of Rubber Goods—be they Synthetic, Natural, or Reclaimed.

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MARKET REVIEWS

RUBBER

Prices on both the physical and futures rubber markets rose over the period from June 16 to July 15, with the former developing pronounced fluctuations while rising at least 1¢ a pound for all stocks and more than 3¢ a pound for No. 1 Thick Latex Crepe. The futures market prices increased between ½ and ¾¢ a pound in all months.

Futures on the Commodity Exchange regisered record activity on July 1 when 370 lots were traded. This point, the highest since trading was resumed, exceeded the previous daily record volume of 342 lots traded on April 9. It was followed the next day by a volume of 274 lots changing hands. Prices were drawn up by the volume of trading, reaching period highs during the following days. September futures, for example, reached 25.07¢ on July 6, after having started the period at 23.75¢, dropped to a low of 23.40¢ on June 18 and 21, and then rose with minor fluctuations to the 25.07¢ figure. A decline followed the peak, and September futures closed the period at 24.30¢.

Reasons for these fluctuations according to seasoned observers, were the synthetic rubber price increases announced by the Reconstruction Finance Corp. on June 30 (see below), the deteriorating military situation in Indo-China, and an announcement that Indonesia began shipments of crude rubber to China.

COMMODITY EXCHANGE
WEEK-END CLOSING PRICES

Futures	Apr. 24	May 29	June 19	June 26	July 3	July 10
Sept.	22.45	23.00	23.40	23.60	25.00	24.30
Dec.	22.90	23.40	23.70	23.80	25.30	24.65
1955						
Mar.	22.85	23.45	23.82	24.10	25.65	24.80
May	22.85	23.50	23.95	24.24	25.80	25.00
July	——	23.50	24.00	24.35	25.90	25.15
Total weekly sales, tons	7,950	2,660	4,200	3,460	8,610	5,120

NEW YORK SPOT MARKET
WEEK-END CLOSING PRICES

	Apr. 24	May 29	June 19	June 26	July 3	July 10
R. S. S.: #1	22.25	22.63	23.25	23.63	24.75	24.75
2	21.88	22.38	23.13	23.50	24.63	24.63
3	21.38	22.25	23.00	23.38	24.50	24.50
Latex Crepe						
#1 Thick	25.50	28.63	31.00	32.50	34.50	34.00
Thin	24.88	25.75	26.25	27.38	29.50	29.00
#3 Amber Blankets	20.75	21.75	22.88	23.25	24.50	24.25
Thin Brown Crepe	19.38	20.75	21.88	22.13	23.50	23.50
Flat Bark	16.25	17.00	18.38	19.00	20.50	20.50

Futures sales during the second half of June amounted to 8,180 tons, making a total for that month of 15,660 tons. During the first half of July, sales of futures totaled 15,510 tons.

Prices on the spot market followed the same general trend as on the futures market, rising to a high on July 6. Apparently the same causes could be attributed to this peak, plus the additional factor that factory demand became active during this time. #1 Ribbed Smoked Sheets started the period at 23.63¢, dropped to a low of 23.25¢ on June 18 and 21, then rose irregularly to a high of 25.25¢ on July 6; a general dropping off then occurred, with the closing price on July 15 being 24.63¢. The other grades followed this same general price pattern.

June monthly average spot prices for certain grades were as follows: R.S.S. #1, 23.27¢; R.S.S. #3, 23.00¢; #3 Amber Blankets, 22.69¢; and Flat Bark, 18.16¢.

A list of prices for all currently available GR-S and GR-I polymers was issued by the Office of Synthetic Rubber, RFC, June 30, as follows:

GR-S POLYMERS

Staining	Price per Pound, ¢
Hot GR-S Non-Pigmented	
1000, 1004, 1007, X-759	23.00
1002, 1005, 1015, 1016, 1023	23.25
1021	24.00
Slightly Staining	
1001	23.00
1014	23.50
Non-Staining	
1006, 1010, 1012, 1013	23.00
1009, 1019	23.25
1018, 1022	23.50
Hot GR-S Black Masterbatches	
Staining	
1100	18.50
Slightly Staining	
1104	18.00
Cold GR-S Non-Pigmented	
Staining	
1500, 1505, X-762	23.00
Slightly Staining	
1501	23.00
Non-Staining	
1502	23.00
1503, 1504	23.25
Cold GR-S Black Masterbatches	
Staining	
1600, 1601, 1602	18.50
Cold GR-S Oil Masterbatches	
100 parts GR-S, 25 parts oil	
1703	19.50
1705, 1706	19.25
100 parts GR-S, 37.5 parts oil	
1707, 1708	18.00
1709, 1710, 1711, 1712	17.75
Cold GR-S Oil Black Masterbatches	
Staining	
1801	17.00
X-763	15.75
GR-I Polymers	
GR-I, 15,* 17,* 18,* 25, 35, 50*	23.00

*Also available packed in coated cartons at the same price.

Latex

The tight situation in natural rubber latex reported last month continued during the period June 16 to July 15. The recently announced increase in the price of GR-S latices had its effect on the natural latex price, and this rose to 35¢ a pound (dry solids) in mid-July.

It is reported that some dealers in the Far East who have been handling drum shipments only are now able to offer shipments in bulk, which represents some possible increase in supply. Since most of this latex comes from Indo-China, however, the future of this increased supply is not clear. Meanwhile, increased business activity predicted for the last half of this year may make the bidding for available supplies more intense.

A list of prices for the various types of GR-S latices currently available was issued by the Office of Synthetic Rubber, RFC, on June 30. These prices, for latex in tank-car quantities (10,000 gallons), follow:

GR-S LATEX PRICES

Hot latices	Price per Lb. ¢
2006	21.50
2000, 2001	22.75
2004	26.00
2003	26.50
2002	27.50
2005	28.00
Cold Latices	
X-617, -734	22.50
X-765	23.50
2100, X-760	25.50
X-667, -711, -758	26.00
X-684, -710	26.75
X-633	27.50

Final April and preliminary May domestic statistics for natural and synthetic rubber latices follow:

(All Figures in Long Tons, Dry Weight)

	Production	Imports	Consumption	Month-End Stocks
Natural latices				
Apr.	0	5,663	5,892	10,803
May	0	5,000	6,101	8,765
GR-S latices				
Apr.	4,046	0	3,748	5,273
May	3,838	0	3,520	5,290
Neoprene latices				
Apr.	803	0	603	1,062
May	680	0	486	1,133
Nitrile latices				
Apr.	461	0	324	600
May	623	0	341	646

SCRAP RUBBER

Light trading characterized activity on the market between June 16 and July 15, with most of the July orders filled. The relative slowness of trading in the East was reportedly due to vacation shutdowns at some factories and to the possibility of labor troubles. Both of these factors seem to have cancelled out the changes expected as a result of the increased prices for government synthetic rubbers.

Only one price change, that for synthetic Butyl auto tubes, was noted over the period. The new price, along with dealers' buying prices for other scrap rubber grades, in carload lots delivered to mills at the points indicated, are given as follows:

	Eastern Points	Akron, O.
	(Per Net Ton)	
Mixed auto tires	$9.00	$11.50
S. A. G. auto tires	Nom.	13.00
Truck tires	Nom.	14.00
Peelings, No. 1	40.00/41.00	40.00/42.00
2	Nom.	Nom.
3	15.50	Nom.
Tire buffing	18.00/20.00	16.00/17.00
	(¢ per Lb.)	
Auto tubes, mixed	2.75	3.00
Black	4.50	4.75
Red	7.50	8.00
Butyl	2.25	2.38

RECLAIMED RUBBER

Light trading prevailed on the reclaimed rubber market for the period from June 16 to July 15 in view of the shutdown of several plants for vacations and the possibility of labor difficulties.

Final April and preliminary May statistics on the domestic reclaim industry have been issued. April figures, in long tons, were: production, 21,628; imports, 30; consumption, 21,883; exports, 1,050; and month-end stocks, 31,359. Preliminary data for April, also in long tons, were: production, 21,158; imports, 54; consumption, 20,425; exports, 940; and month-end stocks, 31,614.

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WANTED: A PURCHASING AGENT FOR SMALL MIDWEST rubber company. Must have thorough knowledge of stampings, forgings, castings, screw-machine products, molds, jigs, and fixtures as well as rubber manufacturing materials. Applicant should be able to negotiate blueprint changes, price, and follow-up of same. Address Box No. 1537, care of RUBBER WORLD.

RUBBER COMPOUNDER. COMPOUNDER WITH MINIMUM EXperience of five years in either belting, hose, tires, or molded rubber goods. Must be capable of developing new formulas and production follow-up on mixing, extrusion, and calendering. Write: GATES RUBBER COMPANY, Denver, Colorado.

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NEW ENGLAND MECHANICAL RUBBER MANUFACTURER wants a man who can develop compounds and products for Hydraulic Seals, Rubber-to-Metal, Aircraft Fuel Valve Diaphragms, and for many other applications to rigid specifications. This man should have the ability to find the job at the customers' drawing board and carry it through our laboratory, production, and inspection departments and back to customers' inspection department. This requires **TECHNICAL, PRODUCTION, AND SALES ABILITY** all in one man. It is an **UNUSUAL JOB FOR AN UNUSUAL MAN** with an unusual opportunity for high earnings and security in proportion to the individual's achievements. Write giving age, experience, and education. All replies held confidential. Address Box No. 1543, care of RUBBER WORLD.

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ACCUMULATOR—A. O. SCHMIDT: 1300 PSI on vessel; new '45 ASME inspected; used 6 mos; tested 2600#; dim 42" x 36'; 1" plate; approx. 4000 gallons capacity; in good condition.
CALENDER—FARREL 3-ROLL: 18" x 54"; 75 HP 3/60/440 V; drive & brake; gear reducer; all controls; NO REASONABLE OFFER REFUSED.
COMPRESSORS—INGERSOLL RAND: 100—1575 CFM; good condition.
EXTRACTORS—TOLHURST: 50" dia.; 29" deep; used for spraying rubber goods; almost new; very good condition.
HOT PLATES: 36" x 36" (25 available for sale).
LIFT TABLES: (3 avail.); 8" ram; 20" stroke; 30" x 22" hydr.
MILL—VAUGHN 22" x 20" x 60": 14" dia. necks; Scott reduction unit; 125 HP Westinghouse motor; good condition.
MILL—FARREL 16" x 54": 50 HP West. 3/60/440 V motor drive; 575 RPM controller; magnetic brake. complete ..... $2975.
PRESS 450 T. SHERIDAN: 4-post hydraulic type; good con.
PRESS—FARREL 157 T.: 16" stroke; 14" ram; 36" x 36" bed.
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SCALE—TOLEDO CONTINUOUS WEIGHER: type 9500 for weighing material coming off rubber calenders.

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1—Adamson 5'x28' Vulcanizer, quick-opening door, A.S.M.E.; 1—5'x12' quick-opening door, 125 psi.
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1—6"x12" Laboratory Mill, m.d.
1—Ball & Jewell #2 Rotary Cutter, 15 HP Motor.
3—#28 Devine Vac. Shelf Dryers, 19-59"x78" shelves, complete. Also other sizes Hydraulic Presses, Tubers, Banbury Mixers, Mills, Vulcanizers, Calenders, Pellet Presses, Cutters.

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There were no changes in reclaimed rubber prices during the period, and current prices follow:

Reclaimed Rubber Prices

	Lb.
Whole tire: first line	$0.10
Fourth line	.0875
Inner tube: black	.15
Red	.21
Butyl	.125
Pure gum, light colored	.23
Mechanical, light colored	.135

The above list includes those items or classes only that determine the price basis of all derivative reclaim grades. Every manufacturer produces a variety of special reclaims in each general group separately featuring characteristic properties of quality, workability, and gravity at special prices.

COTTON FABRICS

Following the virtual withdrawal of cotton ducks from the market because of the low prices in effect during the first part of the June 16-July 15 period, most producers advanced their prices from 3-5¢ a pound on Army ducks, hose and belting ducks, chafers, and numbered ducks. Many observers feel that the increases have been overdue since these fabrics have been selling at a substantial loss for some time.

On other fabrics during the period, the wide industrial materials were relatively quiet, owing probably to present and coming vacations. Many looms have been shifted from the previously low priced ducks to drills and twills, but the increased duck prices may cause them to revert to their original production within the near future.

Sheetings were sold in small quantities over most of the period, with increased sales being recorded toward the end. Print cloths were in great demand until June 25, when Class A prints were advanced ¼¢ a yard for many sizes; demand for these stocks was subsequently reduced, although some increase in activity was noted toward the end of the period.

Selling prices, f.o.b. shipping point, were as follows on July 15:

Cotton Fabrics

Drills		
59-inch 1.85-yd.	*yd.*	$0.35
2.25-yd.		.30
Osnaburgs		
40-inch 2.11-yd.	*yd.*	.24
3.65-yd.		.1525/ $0.155
Ducks		
38-inch 1.78-yd. S. F.	*yd.*	nom.
2.00-yd. D. F.		.33⅝
51.5-inch, 1.35-yd. S. F.		.49⅝
Hose and belting		.67
Raincoat Fabrics		
Printcloth, 38½-inch, 64x64	*yd.*	.135
Sheeting, 48-inch, 4.17-yd.		.20
52-inch, 3.85-yd.		.21 / .2125
Chafer Fabrics		
14.30-oz./sq. yd. Pl.	*lb.*	.73
11.65-oz./sq. yd. S.		.65
10.80-oz./sq. yd. S.		.6875
8.9-oz./sq. yd. S.		.70
Other Fabrics		
Headlining, 59-inch, 1.65-yd., 2-ply	*yd.*	.465 / .4675
64-inch, 1.25-yd., 2-ply		.60
Sateens, 53-inch, 1.32-yd.		.5375/ .54
58-inch, 1.21-yd.		.59

United States Rubber Statistics—April, 1954

(All Figures in Long Tons, Dry Weight)

	New Supply			Distribution		Month-End Stocks
	Production	Imports	Total	Consumption	Exports	
Natural rubber and latex, total	0	49,855	49,855	51,451	918	106,564
Rubber, total	0	44,192	44,192	45,559	918	95,761
Latex, total	0	5,663	5,663	5,892	0	10,803
Synthetic rubbers, total	*40,221 †7,360	1,220	48,801	53,654	2,332	174,983
GR-S types‡	*34,384 †114	1,053	35,551	41,324	520	136,446
Butyl	*5,837	167	6,004	6,241	62	21,673
Neoprene‡	†5,601	0	5,601	4,694	1,296	12,665
Nitrile type‡	†1,645	0	1,645	1,395	454	4,199
Natural rubber and latex, and synthetic rubbers, total	47,581	50,975	98,656	105,105	3,250	281,547
Reclaimed rubber, total	21,628	30	21,658	21,883	1,050	31,359
GRAND TOTALS	69,209	51,005	120,314	126,988	4,300	312,906

*Government plant production.
†Private plant production.
‡Includes latices.
SOURCE: Chemical & Rubber Division, BDSA, United States Department of Commerce, Washington, D. C

Estimated Pneumatic Casings, Tubes, Camelback Shipments, Production, Inventory; May - April, 1954, May, 1953; First Five Months, 1954-1953

Passenger Casings	Original Equipment	Replacement	Export	Total	Production	Inventory
May, 1954	2,695,389	4,503,068	101,164	7,299,621	6,984,582	12,575,264
Change from previous month				+1.27%	−0.66%	−2.93%
April, 1954	2,785,343	4,327,745	95,018	7,208,106	7,030,579	12,954,839
May, 1953	2,821,524	4,816,445	74,594	7,712,563	7,670,352	13,655,727
First 5 mos., 1954	13,161,507	18,963,365	359,715	32,484,587	32,096,923	12,575,264
1953	14,475,449	20,021,552	221,880	34,718,881	37,085,451	13,655,727
Truck and Bus Casings						
May, 1954	324,171	612,351	83,009	1,019,531	980,413	2,928,289
Change from previous month				−1.45%	−5.20%	−0.78%
April, 1954	345,757	607,407	81,355	1,034,519	1,034,188	2,951,136
May, 1953	378,007	787,995	64,200	1,230,202	1,332,035	3,317,751
First 5 mos., 1954	1,677,094	2,987,389	351,428	5,015,911	5,254,830	2,928,289
1953	2,356,093	3,941,318	287,961	6,585,372	7,051,733	3,317,751
Total Automotive Casings						
May, 1954	3,019,560	5,115,419	184,173	8,319,152	7,964,995	15,503,553
Change from previous month				+0.93%	−1.24%	−2.53%
April, 1954	3,131,100	4,935,152	176,373	8,242,625	8,064,767	15,905,975
May, 1953	3,199,531	5,604,440	138,794	8,942,765	9,002,387	16,973,478
First 5 mos., 1954	14,838,601	21,950,754	711,143	37,500,498	37,351,753	15,503,553
1953	16,831,542	23,962,870	509,841	41,304,253	44,137,184	16,973,478
Tractor-Implement Casings						
May, 1954	176,301	114,362	5,470	296,133	317,675	651,755
Change from previous month	-	-		−19.21%	−1.72%	+3.55%
April, 1954	210,543	146,685	9,295	366,523	323,238	629,381
May, 1953	243,715	114,578	4,765	363,058	336,272	785,808
First 5 mos., 1954	907,955	643,125	30,128	1,581,208	1,393,415	651,755
1953	1,411,813	672,451	26,447	2,110,711	2,017,196	785,808
Passenger, Motorcycle, Truck and Bus Inner Tubes						
May, 1954	3,017,308	2,900,378	84,345	6,002,031	5,908,880	11,170,315
Change from previous month				+0.02%	−5.70%	−0.57%
April, 1954	3,133,534	2,769,816	97,190	6,000,540	6,266,271	11,233,717
May, 1953	3,198,824	3,307,154	71,190	6,577,168	6,916,555	12,591,578
First 5 mos., 1954	14,835,255	15,244,372	387,205	30,466,832	29,864,974	11,170,315
1953	16,835,949	16,775,948	282,213	33,894,110	34,658,150	12,591,578
Camelback (Lbs.)						
May, 1954	—	21,669,873	486,570	22,156,443	23,018,008	25,929,234
Change from previous month	—	—	—	−1.95%	+12.34%	+4.56%
April, 1954	—	22,014,290	583,278	22,597,568	20,489,231	24,797,467
May, 1953	—	18,872,000	465,920	19,337,920	20,280,960	34,081,600
First 5 mos., 1954	—	102,796,849	3,844,190	106,641,039	106,428,207	25,929,234
1953	—	101,225,600	3,586,240	104,811,840	115,071,040	34,081,600

NOTE: Cumulative data on this report include adjustments made in prior months.
SOURCE: The Rubber Manufacturers Association, Inc., New York, N. Y.

RAYON

Shipments of rayon by domestic producers in June totaled 94,600,000 pounds, an increase of 3% over the previous month's figure, but 13% below June, 1953, figures. Total production in June was 93,200,000 pounds, or slightly more than 3% more than May's production; and month-end stocks were placed at 95,000,000 pounds, or a little more than 2% under the previous month's level.

Viscose high-tenacity rayon yarn figures for June were as follows: calculated production, 26,300,000 pounds (7% below May's total); total shipments, 25,000,000 pounds (almost 8% below May shipments); and end-of-month stocks, 14,800,000 pounds (an increase of almost 9% over the May level).

For the first six months of 1954, total shipments of rayon amounted to 530,400,000 pounds, much less than the 619,200,000 pounds shipped during the 1953 period.

No changes were made in rayon tire yarn and fabric prices during the period from June 16 to July 15, and current prices follow.

Rayon Prices

Tire Yarns		
1100/ 480	$0.26	$0.63
1100/ 490		.62
1150/ 490		.62
1165/ 480		.63
1650/ 720		.61
1650/ 980		.61
1820/ 980		.61
2200/ 960		.60
2200/ 980		.60
2200/1466		.67
4400/2934		.63
Tire Fabrics		
1100/490/2		.72
1650/980/2	.659	.73
2200/980/2		.685

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Continued

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1—Adamson Vulcanizer, 2' x 12' with quick opening door.
1—J. P. Devine Double Door Vacuum Shelf Dryer, 13 Shelves.
1—Buflovak Double Door Vacuum Shelf Dryer, 20 Shelves.
1—Devine Double Door Vacuum Shelf Dryer, 13 Shelves.
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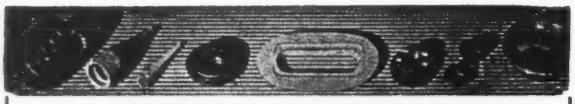

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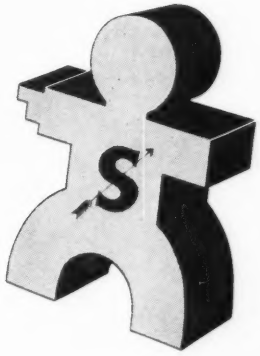

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